IMAGE: A MAP OF THE STARS OF THE ORION CONSTELLATION

JournalPreview

London Journal of Medical & Health Research

Volume 25 | Issue 8 | Compilation 1.0

Great Britain Journals Press

WWW.JOURNALSPRESS.COM

Journal Content
In this Issue

Great Britain Journals Press

From Algorithms to Outcomes: Transforming Modern Healthcare through Artificial Intelligence

Amol Amonkar, Ella-Marie Filinto-Sequeira, Pooja Prashant Kirtani, Mayble Fernandes, Wilroy Gonsalves, Abigail Coutinho, Swizel Ann Cardoso & Shanice Marisa Gouveia

University Hospitals Birmingham NHS Foundation Trust

ABSTRACT

Artificial Intelligence (AI) refers to the utilisation of computers and advanced technologies to simulate intelligent behaviour and critical thinking comparable to that of humans. The term was first described by John McCarthy in 1956 as the science and engineering of creating intelligent machines. [1,2]. Previously considered a concept of science fiction, AI is now a tangible reality and is widely represented within academic discussion and mainstream applications. Machine Learning (ML), which is a subset of AI, enables machines to learn from patient data and generate predictions by pattern recognition, thereby empowering healthcare providers in delivering better care through accurate diagnosis and treatments. Although current technologies and AI models have not yet advanced to a stage where they may replace a doctor, they hold considerable promise as valuable diagnostic tools in healthcare. [1,3] While the likelihood of AI assuming a significant role in healthcare seems imminent, its evolution is currently tempered by concerns regarding ethical challenges and patient safety. This literature review aims to examine the contemporary applications of AI in healthcare, its potential advantages for both patients and healthcare professionals, and the existing challenges and limitations that may hinder its continued progression. [1,2]

Keywords: artificial intelligence, medicine, future, healthcare.

Classification: NLM Code: W 26.55.A7

Language: English

Great Britain Journals Press

London Journal of Medical & Health Research

Volume 25 | Issue 8 | Compilation 1.0

From Algorithms to Outcomes: Transforming Modern Healthcare through Artificial Intelligence

Amol Amonkar[α], Ella-Marie Filinto-Sequeira[σ], Pooja Prashant Kirtani[ρ], Mayble Fernandes[ↀ] Wilroy Gonsalves[¥], Abigail Coutinho[χ], Swizel Ann Cardoso[ν] & Shanice Marisa Gouveia[ϴ]

ABSTRACT

Artificial Intelligence (AI) refers to the utilisation of computers and advanced technologies to simulate intelligent behaviour and critical thinking comparable to that of humans. The term was first described by John McCarthy in 1956 as the science and engineering of creating intelligent machines. [1,2]. Previously considered a concept of science fiction, AI is now a tangible reality and is widely represented within academic discussion and mainstream applications. Machine Learning (ML), which is a subset of AI, enables machines to learn from patient data and generate predictions by pattern recognition, thereby empowering healthcare providers in delivering better care through accurate diagnosis and treatments. Although current technologies and AI models have not yet advanced to a stage where they may replace a doctor, they hold considerable promise as valuable diagnostic tools in healthcare. [1,3] While the likelihood of AI assuming a significant role in healthcare seems imminent, its evolution is currently tempered by concerns regarding ethical challenges and patient safety. This literature review aims to examine the contemporary applications of AI in healthcare, its potential advantages for both patients and healthcare professionals, and the existing challenges and limitations that may hinder its continued progression. [1,2]

Keywords: artificial intelligence, medicine, future, healthcare.

Author α: Goa Medical College, Goa, India.
σ: Good Hope Hospital, University Hospitals Birmingham NHS Foundation Trust, Birmingham, United Kingdom.
ρ: Norfolk and Norwich University Hospitals NHS Foundation Trust, Norwich, United Kingdom.
ↀ: Community CAMHS, North East London Foundation Trust, Canterbury, United Kingdom.
¥: Southampton General Hospital, Southampton, United Kingdom.
χ: Orpington Hospital, Kings College Hospital NHS Foundation Trust, London, United Kingdom.
ν: Doncaster Royal Infirmary, Doncaster and Bassetlaw Teaching Hospitals NHS Foundation Trust, United Kingdom.
ϴ: Wexham Park Hospital-Frimley NHS Foundation Trust, United Kingdom.

I. INTRODUCTION

Artificial Intelligence (AI) is defined as the utilisation of computers and advanced technologies to emulate intelligent behaviour and critical thinking comparable to that of human beings. [1,13] The term "artificial intelligence" was first conceptualised by John McCarthy in the 1950s, and he later defined AI as the science and engineering of creating intelligent machines. Alan Turing, a pioneer in the fields of contemporary computing and artificial intelligence, in his 1950 essay "Computing Machinery and Intelligence" introduced the "imitation game", now known as the Turing Test [1,5], which hypothesised that a computer may be considered intelligent if it is able to achieve human-level performance in cognition-related tasks. [1,20] The 1980s and 1990s witnessed a surge in interest in AI, which ushered in the introduction of artificial intelligence methodologies within different clinical settings in healthcare, and by 2016, healthcare applications represented the predominant share of spending in AI research relative to other sectors. [1,3]

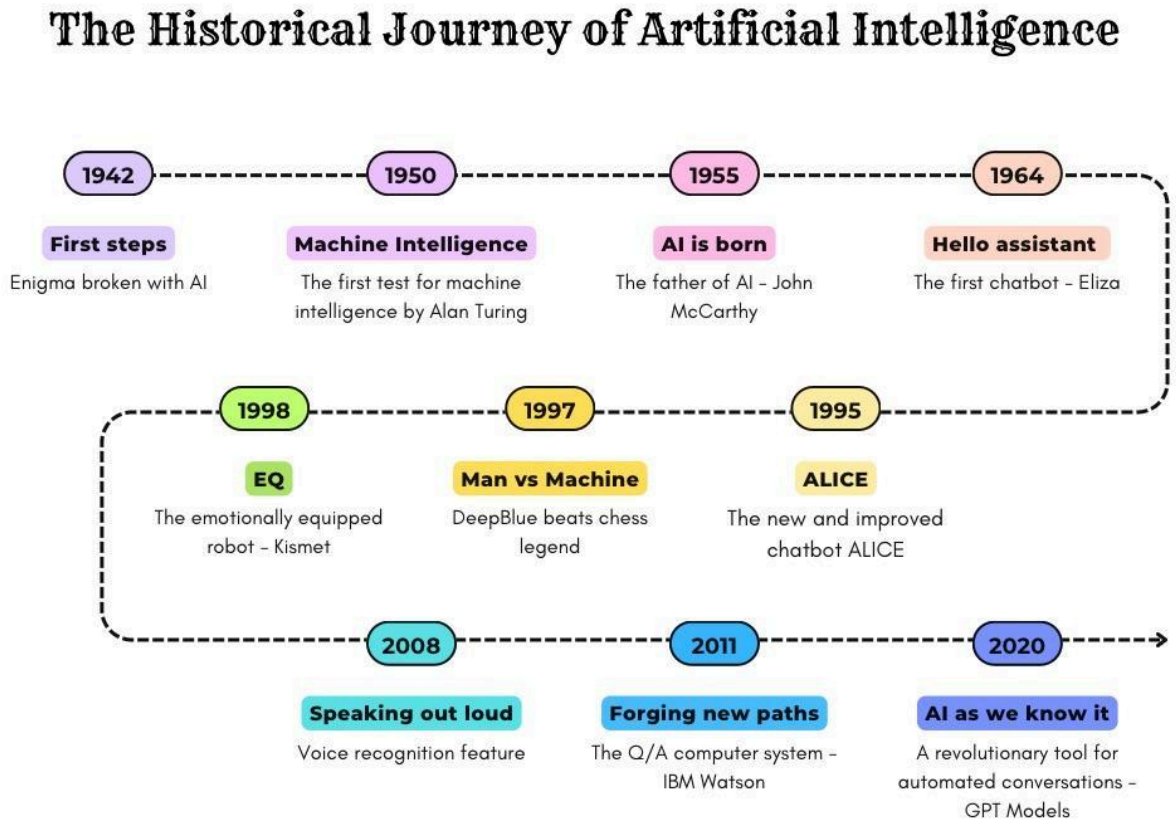


Figure 1

The application of AI in medicine can be broadly classified into two categories: virtual and physical. While the virtual part encompasses applications such as electronic health record systems to neural network-based guidance in treatment decisions [1,6], the physical elements deal with robot-assisted surgeries and smart artificial limbs that utilise AI to enhance movement, comfort, and control for individuals with limb loss[1,9].

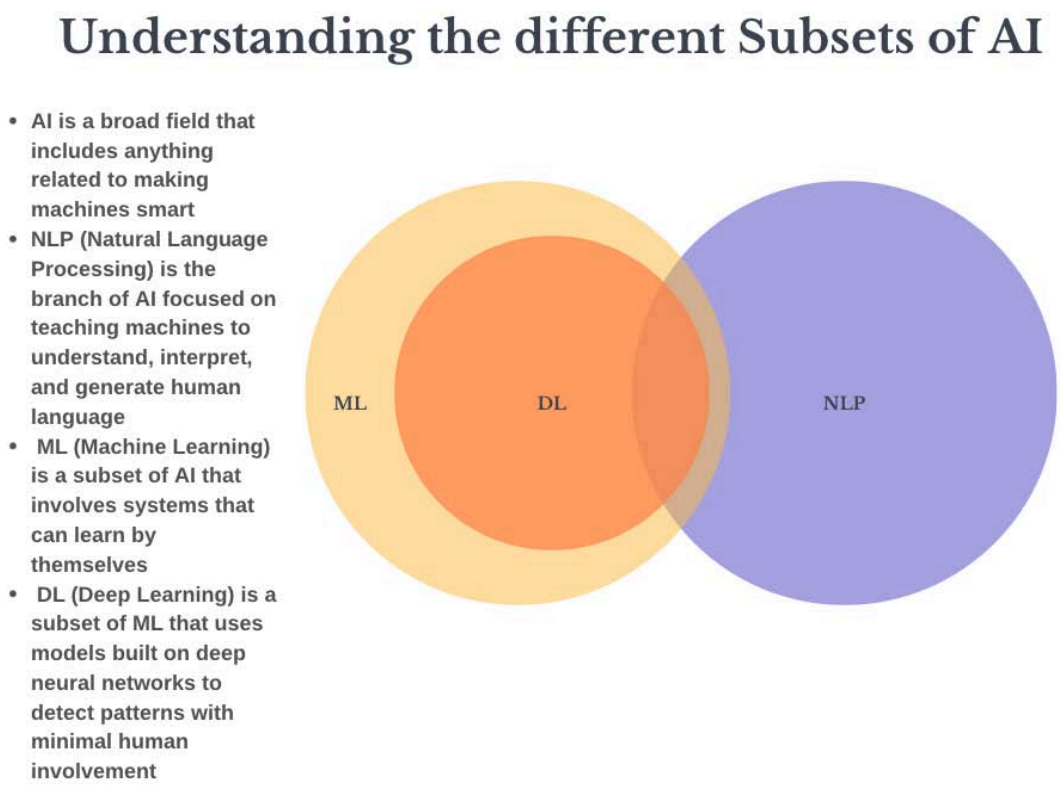


Figure 2

Evidence-based medicine relies on establishing clinical correlations by identifying causal connections and trends from existing repositories of information. [1, 14]. Two broad approaches have been used to model computer-assisted diagnosis by AI models, namely flowchart-driven systems and the database or deep-learning approach. In the former, the process of history taking is formalised as a sequence of questions and branching rules that map symptom constellations to arrive at a differential diagnosis [1, 2, 3]. Implementing such systems typically entails feeding large volumes of data and clinical information into machine-based cloud networks so as to accommodate the breadth of signs and symptoms encountered in clinical settings [1, 22]. Despite the breadth of their knowledge and questions, these systems remain constrained by their inability to pick up on subtle and context-dependent cues that clinicians extract during an in-person consultation, which limits their diagnostic performance in real-world clinical settings [1, 26].

On the other hand, a database approach is based on deep learning and pattern recognition. This process involves training a computer via iterative algorithms to identify certain groups of symptoms or particular clinical or radiological findings. [1, 33]. A frequently cited illustration is Google's "artificial brain" project (2012), in which an unsupervised system exposed to approximately ten million YouTube frames progressively improved its ability to detect cats; after five days of training, it achieved 75% accuracy on that task [1, 42]. The effectiveness of database approaches, however, is limited by the representativeness and labelling fidelity of training data.

II. REVIEW OF LITERATURE

The incorporation of Artificial Intelligence (AI) into the health sector is expected to majorly impact every aspect of primary care. AI-enabled computer applications could allow primary care physicians to effectively identify patients who require additional attention and formulate tailored protocols for each individual. [1,32] Furthermore, physicians can utilise AI in clinical

documentation for transcribing notes, analysing consultations with patients, and automatically feeding necessary information into the systems. [1, 25] These applications can gather and analyse patient data, hence providing primary care providers with in-depth insights into patients' medical needs. [1, 41] A study conducted in 2016 reported that physicians spend only 27% of their office day on direct clinical face time with their patients, while 49.2% of their office day is spent on electronic health records (EHR) and other tasks. In a nutshell, it was found that physicians utilising documentation help, such as dictation assistance or medical scribe services, interacted more directly with patients compared to those who did not employ these services. [1, 37]

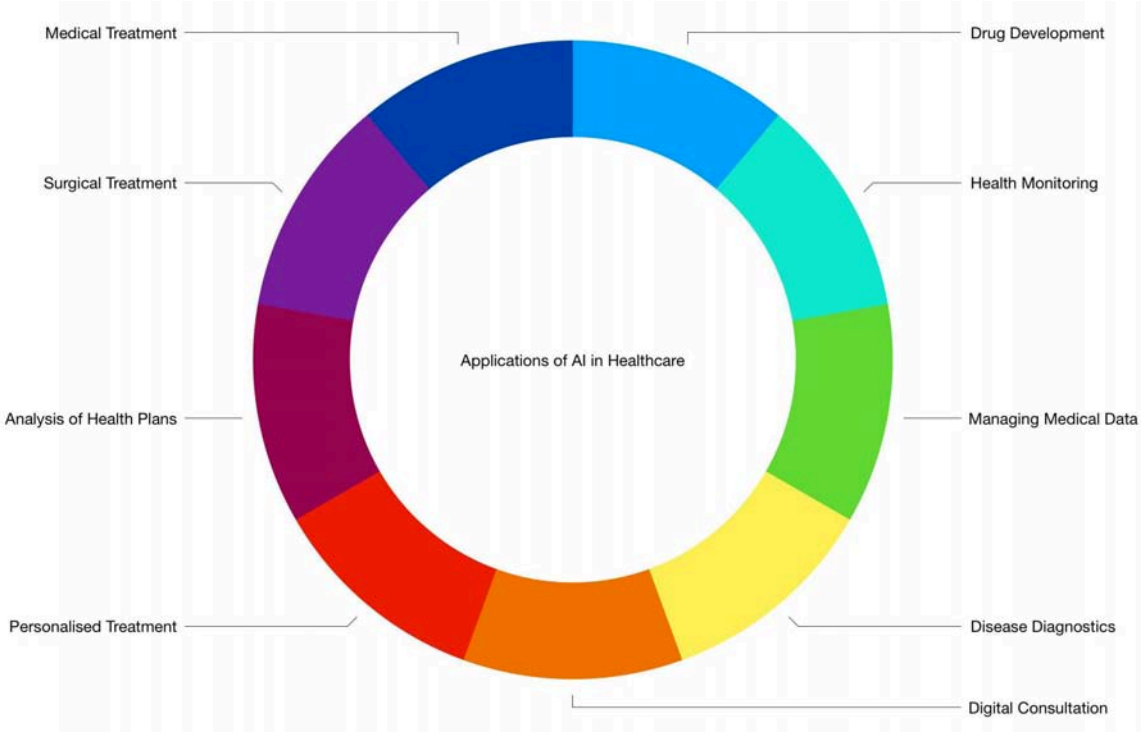


Figure 3

Research and development of pharmaceutical agents for specific diseases through clinical trials typically requires many years and substantial financial investment [1, 2, 3, 4]. To quote an example, AI has been employed to screen existing medications with potential efficacy against the Ebola virus menace, a task that would have otherwise taken years using traditional methods. [1, 45] With the help of AI, we will be able to embrace the new concept of "precision medicine". [1, 18] Several research studies have shown instances whereby AI technology was able to outperform dermatologists in correctly classifying suspicious skin lesions because an AI system can synthesise evidence from an exponentially large data set of patient images within minutes, which is more than a doctor could assess in a lifetime. [1, 23] AI-based decision-making methodologies could be utilised in situations characterised by expert disagreement, and a notable example of this has been in the identification of pulmonary tuberculosis on chest radiographs, with some AI-powered tools demonstrating high sensitivity and specificity. [1, 31]

The emergence of AI in healthcare settings has elicited a balanced response of both optimism and scepticism. While its proponents highlight its potential to revolutionise healthcare; many current and aspiring medical professionals express concern over a possible reduction in job opportunities due to increased automation [1, 27].

Although machines can simulate certain aspects of human behaviour and reasoning through logical and analytical processing, they still fall

short of replicating inherently human traits, such as emotional intelligence, imaginative thinking, and interpersonal relationships. [1, 15]

A notable example illustrating the limitations of AI in medicine is the Digital Mammography Dream Challenge (2016). This extensive study used several computer networks in order to create an AI algorithm that analysed 640,000 digital mammograms. [1, 21] The best-performing model achieved a specificity of 0.81, a sensitivity of 0.80, and an area under the receiver operating characteristic (ROC) curve of 0.87. These results corresponded to the performance level of the bottom 10% of radiologists. [1, 40] This fact underscored that while AI shows promise, it is unlikely to replace physicians entirely in the near future. [1, 47]

Among the medical specialities, radiology has been the most proactive in adapting to new technologies. [1,34] Initially, computers were utilised for administrative tasks such as image acquisition and storage. However, their role has expanded significantly with the advent of Picture Archiving and Communication Systems (PACS), making them an essential part of the radiological workflow. [1, 28] The application of Computer-Aided Detection (CAD) in screening mammography is well documented. Nevertheless, recent studies suggest that CAD has limited diagnostic value, particularly in terms of its sensitivity, specificity, and positive predictive value. [1, 18] Moreover, high rates of false positives can lead to unnecessary follow-ups, potentially distracting radiologists and increasing workload. [1, 30]

Nevertheless, emerging research indicates that AI could offer substantial support in radiology. Beyond merely flagging abnormal cases, AI systems could expedite the review of negative studies-such as CT scans, X-rays, and MRIs-especially in high-volume clinical settings or hospitals with limited staffing. This dual capability could significantly enhance efficiency and resource allocation in diagnostic imaging departments. [1,12]

The University of Massachusetts developed a decision support system known as DXplain in 1986. Based on complex symptom inputs, it generates a list of probable differential diagnoses and serves as a popular educational tool for medical students. [1, 29] Similarly, Germ Watcher, developed by the University of Washington, is a system designed to detect and investigate hospital-acquired infections, helping improve infection control in healthcare settings. [1, 44]

In the UK, an online application called Babylon enables patients to consult doctors online, check symptoms, receive medical advice, monitor their health, and order test kits. This tool exemplifies the increasing integration of AI into accessible patient care. [1, 50]

Beyond diagnostics, AI is also playing a role in therapy. AI Therapy is an online course developed from a programme at CBTpsych.com at the University of Sydney. It uses the cognitive behavioural therapy (CBT) approach to help patients manage and treat social anxiety. [1, 19]

The Da Vinci Robotic Surgical System, developed by Intuitive Surgical, has revolutionised the field of surgery, particularly in urology and gynaecology. Its robotic arms mimic a surgeon's hand movements with extreme precision, allowing for smaller, more accurate incisions. [1,49]

The National Institutes of Health (NIH) has developed the AiCure app, which uses smartphone webcams to monitor patients' medication intake. This helps reduce non-adherence and ensures better treatment outcomes. [1, 35]

Wearable technology has also made major improvements. Devices like Fitbit, Apple Watch, and other health trackers can now monitor heart rate, activity levels, sleep patterns, and, in some models, even detect ECG changes, expanding their role in preventive healthcare. [1,43]

All of these new developments can help the doctor better understand the patient's condition and notify the user of any variations. In order to prevent needless hospital stays, the Netherlands uses AI for healthcare system analysis, identifying treatment errors and workflow inefficiencies. [1,

38] In addition to existing technologies, certain advances in different stages of development have made physicians better doctors; IBM's Watson Health exemplifies this capability, since it is proficient at efficiently identifying symptoms of heart disease and cancer. [1, 46] A program called AI Assisted Care (PAC) is being developed at Stanford University, which possesses an advanced senior well-being support system and smart ICUs, which can identify any behavioural alterations in elderly people residing alone and ICU patients. This technology extends into intelligent hand hygiene support and healthcare conversational agents. Hand hygiene support uses depth sensors, refining computer vision technology to achieve perfect hand hygiene for clinicians and nursing staff, reducing hospital-acquired infections. Healthcare conversational projects examine how Siri, Google Now, S Voice, and Cortana respond to medical health, interpersonal violence, and physical health. [1, 50]

III. DISCUSSION

All previously mentioned might be viewed as a developing substitute for human labour, particularly in the areas of reasoning and decision-making. [1, 3] This capability can revolutionise the application of AI in medicine by effectively assuming the cognitive skills typically performed by a doctor. [1, 48] Due to certain and obvious safety risks, the unattended use of AI in conventional medicine may not become a possibility, at least in the near future. However, it might assume the majority of the workload associated with non-invasive and diagnostic aspects of medical practice, which is theoretically estimated to improve with the widespread implementation of AI. [1,36]

The exponential growth of data and the training of AI require active use of computers, which leads to increased efficiency in medical practice compared to traditional pen and paper systems; furthermore, improved outcomes over time may demonstrate the reliability of AI and its necessity in medicine. [1, 3]

3.1 Role of AI in Clinical Research

There are several clinical and educational applications of AI programme development in teaching hospitals. AI's ability to process vast amounts of data with precision, reduce human errors, and automate repetitive tasks makes it indispensable for cataloguing and highlighting multiple pathologies based on their features, which can lead to numerous breakthroughs in clinical research. [1, 2] Beyond decision-making, more specific applications of computer vision include research undertakings such as examination of patient cohorts, as well as longitudinal studies through image-based analysis. [1, 3]

3.2 AI in Predictive and Preventive Medicine

Electronic health records may be analysed by AI algorithms to predict readmission risks, disease progression, and patient outcomes.

Some examples of the same include early warning systems, which using AI can predict sepsis several hours before clinical manifestation. Another example is cardiac arrest assessment, where AI-enhanced ECG interpretation can predict atrial fibrillation and myocardial infection risk with high sensitivity. [1, 4]

Predictive AI tools also aid in outbreak monitoring, such as AI systems used during the COVID-19 pandemic to forecast disease spread and allocate resources. [1, 6]

3.3 AI in Surgical Practice

AI enhances robot-assisted surgeries by offering real-time navigation, image guidance, and haptic feedback. Systems like the da Vinci Surgical System are evolving towards semi-autonomous capabilities. [1,40] AI can evaluate surgical techniques by analysing video feeds, providing objective feedback, and enabling skill development. The use of AI in highly technical surgeries such as neurosurgery in the form of robotics and technologies can assist in minimally invasive surgery and reduce negative patient outcomes. [1, 10]

3.4 Drug Discovery and Personalised Medicine

AI has been utilised to develop vaccines and pharmaceuticals, and this process is expected to be expedited, as evidenced during COVID-19 vaccine development. [1,39] AI can also be advantageous in clinical trials as well as during pharmacotherapeutic research. With ever-evolving AI systems through the upcoming years, there is a future possibility for AI to integrate and analyse patient details to generate their "digital twins", which can serve as virtual subjects for evaluating drug and treatment safety and efficacy. [1,46]

3.5 Virtual Health Assistants and Clinical Decision Support

Chatbots and AI-powered virtual assistants, such as Babylon Health and Ada, help with appointment scheduling, patient triage, and symptom checks. Clinical decision support systems powered by AI examine patient data to identify abnormal lab results or provide diagnostic recommendations. [1] An early example was IBM Watson, which provided cancer therapy alternatives based on evidence and clinical guidelines. [1, 9]

3.6 Hospital and Administrative Applications

AI optimises hospital workflow by predicting bed occupancy, automating documentation and coding, and managing supply chain logistics. [1,24]

3.7 Challenges

Some limitations currently prevent a broader use of AI and its subfields, despite the increasing interest surrounding AI, its substantial integration in healthcare, and its advantages in patient management. [1,7] There are certain challenges to the practical and sustainable use of AI, such as financial and maintenance issues that also require training of staff as well as doctors. It has been found that doctors are apprehensive about the imminent integration of AI into their careers. [1, 11]

Optimal operation of this technology in generating appropriate responses and performing certain tasks necessitates a large amount of data input, including hospital records and medical reports. [1, 8] Providing a significant chunk of data, which may include confidential information and patient particulars, to train and create the algorithms may provide challenges. Moreover, the AI algorithms employed to train them can introduce bias stemming from the interpretations of available data, potentially influencing critical clinical and surgical decisions in the future. [1, 5]

Another frequently cited limitation of AI in clinical practice is the 'black box' phenomenon, which refers to when algorithms offer interpretations and conclusions with little or no accompanying rationale. [1, 3] The lack of definitive data establishing a cause-and-effect relationship between the variables renders individuals hesitant to trust the technology.

To overcome this, clinicians should acquire foundational literacy in AI methods and collaborate closely with data scientists and engineers to deploy tools that support precise assessment of patient risk and surgical decision-making. [1, 3] Moreover, it is pertinent to periodically update models with new data to counteract distributional shift and to maintain calibration over time [1, 49]. To evaluate and, where appropriate, contest machine-generated decisions, clinicians must understand in broad methodological terms how these systems operate; this presupposes multidisciplinary engagement between clinicians and informaticists, engineers, and other technical experts. [1, 16]

Ethical Considerations

High-quality data is foundational to the safe integration of artificial intelligence within clinical practice. However, errors may be introduced at the point of data capture, whether through human mislabelling, inconsistent documentation, or automated ingestion and preprocessing. This can inadvertently generate systematic bias that propagates through model training and inference, ultimately manifesting as skewed outputs that may be experienced by patients as a lack of empathy or substandard care [1, 7]. These risks foreground ethical concerns regarding the susceptibility of AI systems to corruption and

bias. This is illustrated in facial recognition technology, wherein disparate error rates across certain racial groups underscore the potential for discriminatory harm, risks that would be especially consequential in disciplines such as plastic surgery that rely on image-based assessment and planning [1, 3]. Additionally, the high volume of data required can also pose a risk to patient consent and privacy. Use of AI on patient data demands strict adherence to data protection laws, for example, HIPAA, GDPR, et cetera. [1, 2] There are also risks such as cyberattacks on AI frameworks as well as the evolution of bias in the complex aftermath of the massive digital network that may not be resolvable by simplistic methods. [1,19]

IV. CONCLUSION

AI is rapidly revolutionising the healthcare landscape across multiple specialities. Emerging trends suggest that AI technologies have the potential to enhance patient care by not only strengthening existing clinical pathways but also fostering innovation in practice and surgery. The rapid expansion of AI is evident in its widening application across screening, diagnosis, treatment, and disease prevention, ultimately contributing to reductions in both mortality and morbidity. Nevertheless, continued research is essential to ensure the optimal and equitable implementation of AI and to address ongoing challenges such as limitations in data representativeness and generalisability, insufficient AI training, human resistance, automation bias, ethical considerations, and concerns regarding workforce stability.

Abbreviations

AI: Artificial Intelligence,
EHR: Electronic Health Record,
CAD: Computer-Assisted Diagnosis

REFERENCES

1. Amisha, Malik P, Pathania M, Rathaur VK. Overview of artificial intelligence in medicine. J Family Med Prim Care. 2019 Jul; 8(7): 2328-2331. doi: 10.4103/jfmpc.jfmpc_440_19. PMID: 31463251; PMCID: PMC6691444.
2. Alowais, S. A., Alghamdi, S. S., Alsuhebany, N. *et al.* Revolutionizing healthcare: the role of artificial intelligence in clinical practice. *BMC Med Educ* 23, 689 (2023). https://doi.org/10.1186/s12909-023-04698-z
3. Amin A, Cardoso S. Future of Artificial Intelligence in Surgery: A Narrative Review. https://www.cureus.com/articles/204683-future-of-artificial-intelligence-in-surgery-a-narrative-review#!/.
4. Matheny ME, Whicher D, Thadaney Israni S. Artificial Intelligence in Health Care: a Report from the National Academy of Medicine. JAMA. 2020; 323(6): 509–10. https://doi.org/10.1001/jama.2019.21579.
5. Davenport T, Kalakota R. The potential for artificial intelligence in Healthcare. Future Healthc J. 2019; 6(2): 94–8. https://doi.org/10.7861/futurehosp.6-2-94.
6. Vanlehn K. The relative effectiveness of human tutoring, intelligent tutoring systems, and other tutoring systems. Educational Psychol. 2011; 46(4): 197–221. https://doi.org/10.1080/00461520.2011.611369.
7. Jordan MI, Mitchell TM. Machine learning: Trends, perspectives, and prospects. Science. 2015; 349(6245): 255–60. https://doi.org/10. 1126/science.aaa8415.
8. Topol EJ. High-performance medicine: the convergence of human and artificial intelligence. Nat Med. 2019; 25(1): 44–56.
9. Cruz J, Wishart D: Applications of machine learning in cancer prediction and prognosis cancer informatics. Cancer Inform. 2006, 2:0. 10.1177/117693510600200030
10. Mintz Y, Brodie R. Introduction to artificial intelligence in medicine. Minim Invasive Ther Allied Technol. 2019;28:73–81. doi: 10.1080/13645706.2019.1575882. [DOI] [PubMed] [Google Scholar]
11. Berlyand Y, Raja AS, Dorner SC, Prabhakar AM, Sonis JD, Gottumukkala RV, et al. How artificial intelligence could transform emergency department operations. Am J Emerg Med. 2018; 36(8): 1515–7. https://doi.org/10.1016/j.ajem.2018.01.017.
12. Rajpurkar P, et al. CheXNet: Radiologist-Level Pneumonia Detection on Chest X-Rays with Deep Learning. arXiv 2017.

13. Esteva A, et al. Dermatologist-level classification of skin cancer with deep neural networks. Nature. 2017; 542(7639): 115–118.
14. Haug CJ, Drazen JM. Artificial Intelligence and Machine Learning in Clinical Medicine, 2023. N Engl J Med. 2023; 388(13): 1201–8. https://doi.org/10.1056/NEJMra2302038.
15. Hamlet P, Tremblay J. Artificial intelligence in medicine. Metabolism. 2017; 69S: S36–40. doi:10.1016/j.metabol.2017.01.011. [DOI] [PubMed] [Google Scholar]
16. Clark L, editor. Google's Artificial Brain Learns to Find Cat Videos. [Last accessed on 2019 Mar 27]; Wired UK Science. 2012 Available from: http://www.wired.com/2012/06/google-xneural-network. [Google Scholar]
17. Markoff J, editor. New York Times: 2012. [Last accessed on 2019 Mar 27]. How Many Computers to Identify Cat? 16,000. Available from: http://www.nytimes.com/2012/06/26/technology/in-a-big-network-ofcomputers-evidence-of-machine-learning.html. [Google Scholar]
18. Mayo RC, Leung J. Artificial intelligence and deep learning-Radology's next frontier? Clin Imaging. 2018; 49: 87–8. doi:10.1016/j.clinimag.2017.11.007. [DOI] [PubMed] [Google Scholar]
19. Fenton JJ, Taplin N. Influence of computer-aided detection on performance of screening mammography. Engl J Med. 2007; 356: 1399–409. doi:10.1056/NEJMoa066099. [DOI] [PMC free article] [PubMed] [Google Scholar]
20. Alcusky M, Philpotts L, Bonafede M, Clarke J, Skoufalos A. The patient burden of screening mammography recall. J Womens Health (Larchmt) 2014; 23 (Suppl 1): S11–9. doi: 10.1089/jwh.2014.1511. [DOI] [PubMed] [Google Scholar]
21. London S. DXplain: A web-based diagnostic decision support system for medical students. Med Tef Serv Q. 1998; 17: 17–28. doi: 10.1300/J115v17n02_02. [DOI] [PubMed] [Google Scholar]
22. Kahn MG, Steib SA, Fraser VJ, Dunagan WC. An expert system for culture-based infection control surveillance. Proc Annu Symp Comput Appl Med Care. 1993:171–5. PMID: 8130456. [PMC free article] [PubMed] [Google Scholar]
23. McCall HC, Richardson CG, Helgadottir FD, Chen FS. Evaluating a web-based social anxiety intervention: A randomized controlled trial among university students? J Med Internet Res. 2018; 20: e91. doi: 10.2196/jmir.8630. doi: 10.2196/jmir.8630. [DOI] [PMC free article] [PubMed] [Google Scholar]
24. Barlett J, editor. Buoy health has announced that it will broaden its self-diagnostic tool into pediatric illnesses through a partnership with Boston Children's Hospital. Boston Business Journal. 2018. [Last accessed on 2019 Mar 27]. Available from: https:// www.bizjournals.com/boston/news/2018/08/22/boston-childrens-website-to-feature-self.html .
25. Labovitz DL, Shafner L, Reyes Gil M, Virmani D, Hanina A. Using artificial intelligence to reduce the risk of nonadherence in patients on anticoagulation therapy. Stroke. 2017; 48: 1416–9. doi:10.1161/strokeaha.116.016281. [DOI] [PMC free article] [PubMed] [Google Scholar]
26. Pusiol G, Esteva A, Hall SS, Frank M, Milstein A, Fei-Fei L, et al. Classification of developmental disorders using eye-movements. International Conference on medical imaging computing and computer-assised intervention (MICCAI) 2016. Oct, [Last accessed on 2019 Mar 27]. Available from: https://med.stanford.edu/cerc/research/new-pac.html .
27. Bianconi GM, Mehra R, Yeung S, Salipur F, Jopling J, Downing L, et al. Vision-based prediction of ICU mobility care activities using recurrent neural networks. Machine learning for health workshop, Neural information processing systems (NIPS) 2017. Dec, [Last accessed on 2019 Mar 27]. Available from: https://med.stanford.edu/cerc/research/new-pac.html.
28. Haque A, Guo M, Alahi A, Yeung S, Luo Z, Rege A, et al. Towards vision-based smart hospitals: A system for tracking and monitoring hand hygiene compliance. Machine learning in healthcare conference (MLHC) 2017. Aug, [Last accessed on 2019

Mar 27]. Available from: https://med.stanford.edu/cerc/research/new-pac.html.
29. Sinsky C, Colligan L, Li L, Prgomet M, Reynolds S, Goeders L, et al. Allocation of physician time in ambulatory practice: A time and motion study in 4 specialities. Ann Intern Med. 2016; 165: 753–60. doi:10.7326/M16-0961. [DOI] [PubMed] [Google Scholar]
30. Sorlie T, Perou CM, Tibshirani R, Aas T, Geisler S, Johnsen H, et al. Gene expression patterns of breast carcinomas distinguish tumor subclasses with clinical implications. Proc Natl Acad Sci. 2001; 98: 10869–74. https://doi.org/10.1073/pnas.191367098.
31. Widen E, Raben TG, Lello L, Hsu SDH. Machine learning prediction of biomarkers from SNPs and of Disease risk from biomarkers in the UK Biobank. Genes (Basel). 2021; 12(7): 991. https://doi.org/10.3390/genes12070991. Published 2021 Jun 29.
32. Leek JT, Scharpf RB, Bravo HC, Simcha D, Langmead B, Johnson WE, et al. Tackling the widespread and critical impact of batch effects in high-throughput data. Nat Rev Genet. 2010; 11: 733–9. https://doi.org/10.1038/nrg2825.
33. Yersal O. Biological subtypes of breast cancer: prognostic and therapeutic implications. World J Clin Oncol. 2014; 5(3): 412–24.
34. Tran TTV, Surya Wibowo A, Tayara H, Chong KT. Artificial Intelligence in Drug Toxicity Prediction: recent advances, Challenges, and future perspectives. J Chem Inf Model. 2023; 63(9): 2628–43. https://doi.org/10.1021/acs.jcim.3c00200.
35. Blanco-González A, Cabezón A, Seco-González A, Conde-Torres D, Antelo-Riveiro P, Piñeiro Á, et al. The role of AI in drug discovery: Challenges, opportunities, and strategies. Pharmaceuticals. 2023; 16(6): 891. https://doi.org/10.3390/ph16060891.
36. Han K, Cao P, Wang Y, Xie F, Ma J, Yu M, Wang J, Xu Y, Zhang Y, Wan J. A review of approaches for Predicting Drug-Drug interactions based on machine learning. Front Pharmacol. 2022;12:814858. https://doi.org/10.3389/fphar.2021.814858.
37. Hautz WE, Kämmer JE, Hautz SC, d Disease Risk Prediction. Front Bioinform. 2022; 2: 927312. https://doi.org/10.3389/fbinf.2022.927312. Published 2022 Jun
38. Abubaker Bagabir S, Ibrahim NK, Abubaker Bagabir H, Hashem Ateeq R. Covid-19 and Artificial Intelligence: genome sequencing, drug development and vaccine discovery. J Infect Public Health. 2022; 15(2): 289–96. https://doi.org/10.1016/j.jiph.2022.01.011.
39. Esteva A, Kuprel B, Novoa RA, Ko J, Swetter SM, Blau HM, et al. Dermatologist-level classification of skin cancer with deep neural networks. Nature. 2017; 542: 115–8. doi: 10.1038/nature21056. [DOI] [PMC free article] [PubMed] [Google Scholar]
40. Lakhani P, Sundaram B. Deep learning at chest radiography: Automated classification of pulmonary tuberculosis by using convolutional neural networks. Radiology. 2017; 284: 574–82. doi:10.1148/ radiol.2017 162326. [DOI] [PubMed] [Google Scholar]
41. The digital mammography DREAM challenge. [Last accessed on 2017 Nov 02]. https://www.synapse.org/#!Synapse:syn4224222/wiki/401744.
42. Suleimenov IE, Vitulyova YS, Bakirov AS, Gabrielyan OA. Artificial Intelligence:what is it? Proc 2020 6th Int Conf Comput Technol Appl. 2020; 22–5. https://doi.org/10.1145/3397125.3397141.
43. Vandenberg O, Durand G, Hallin M, Diefenbach A, Gant V, Murray P, et al. Consolidation of clinical Microbiology Laboratories and introduction of Transformative Technologies. Clin Microbiol Rev. 2020; 33(2). https://doi.org/10.1128/cmr.00057-19.
44. Go T, Kim JH, Byeon H, Lee SJ. Machine learning-based in-line holographic sensing of unstained malaria-infected red blood cells. J Biophotonics. 2018; 11(9): e201800101. https://doi.org/10.1002/jbio.201800101.
45. Smith KP, Kang AD, Kirby JE. Automated interpretation of Blood Culture Gram Stains by Use of a deep convolutional neural network. J Clin Microbiol. 2018; 56(3): e01521–17. https://doi.org/10.1128/JCM.01521-17.

46. Peiffer-Smadja N, Dellière S, Rodriguez C, Birgand G, Lescure FX, Fourati S, et al. Machine learning in the clinical microbiology laboratory: has the time come for routine practice? Clin Microbiol Infect. 2020; 26(10): 1300–9. https://doi.org/10.1016/j.cmi.2020.02.006.
47. Undru TR, Uday U, Lakshmi JT, et al. Integrating Artificial Intelligence for Clinical and Laboratory diagnosis - a review. Maedica (Bucur). 2022; 17(2): 420–6. https://doi.org/10.26574/maedica.2022.17.2.420.
48. Mijwil MM, Aggarwal K. A diagnostic testing for people with appendicitis using machine learning techniques. Multimed Tools Appl. 2022; 81(5): 7011–23. https://doi.org/10.1007/s11042-022-11939-8.
49. Becker J, Decker JA, Römmele C, Kahn M, Messmann H, Wehler M, et al. Artificial intelligence-based detection of pneumonia in chest radiographs. Diagnostics. 2022; 12(6): 1465. https://doi.org/10.3390/diagnostics12061465.
50. Blasiak A, Truong A, Jeit W, Tan L, Kumar KS, Tan SB, et al. Precise Curate. Ai: a prospective feasibility trial to dynamically modulate personalized chemotherapy dose with artificial intelligence. J Clin Oncol. 2022; 40(16suppl): 1574–4. https://doi.org/10.1200/JCO.2022.40.16_suppl.1574.

This page is intentionally left blank

Renal Leiomyoma as a Bosniak IV Lesion: A Case Report

Ketully Nayara Bortolozzo

ABSTRACT

Leiomyoma is a benign neoplasm originating from mesenchymal cells, affecting the smooth muscle of the genitourinary tract. These tumors can occur in various places throughout the urinary tract, mainly in the bladder, but renal involvement is less frequent and is usually in the renal capsule.

They are generally asymptomatic, and diagnosis is frequently incidental through imaging studies. When symptomatic, flank pain, palpable abdominal mass or hematuria can be present.

This report describes a patient with lower back pain whose computed tomography (CT) revealed a complex Bosniak IV renal lesion. Later, the patient was submitted to a partial robotic nephrectomy and diagnosed with leiomyoma through immunohistochemistry.

Keywords: leiomyoma, urology, immunohisto- chemistry, renal cyst, radiology; kidney neoplasm.

Classification: NLM Code: WJ 160

Language: English

LJP Copyright ID: 392882

Great Britain Journals Press

London Journal of Medical & Health Research

Volume 25 | Issue 8 | Compilation 1.0

Renal Leiomyoma as a Bosniak IV Lesion: A Case Report

Ketully Nayara Bortolozzo

ABSTRACT

Leiomyoma is a benign neoplasm originating from mesenchymal cells, affecting the smooth muscle of the genitourinary tract. These tumors can occur in various places throughout the urinary tract, mainly in the bladder, but renal involvement is less frequent and is usually in the renal capsule.

They are generally asymptomatic, and diagnosis is frequently incidental through imaging studies. When symptomatic, flank pain, palpable abdominal mass or hematuria can be present.

This report describes a patient with lower back pain whose computed tomography (CT) revealed a complex Bosniak IV renal lesion. Later, the patient was submitted to a partial robotic nephrectomy and diagnosed with leiomyoma through immunohistochemistry.

Keywords: leiomyoma, urology, immunohisto-chemistry, renal cyst, radiology; kidney neoplasm.

I. CASE REPORT

A 44-year-old woman with a history of long-term lower back pain had a contrast-enhanced computed tomography (CT) showing a nodular, solid-cystic lesion in the left kidney, classified as Bosniak IV (Figure1). The mass had a Renal nephrometry score of 8x, measuring 39 mm (1, 54 in).

Due to the clinic-radiologic suspicion of a complex cystic renal neoplasm, a left partial nephrectomy was performed together with an anatomo pathological study of the sample that identified a mesenchymal pattern suggestive of leiomyoma. The sample was then sent to an immuno histochemistry analysis that confirmed the diagnosis of renal leiomyoma.

The patient's condition improved after the surgical intervention.

II. DISCUSSION

Mesenchymal tumors of the kidney, although rare, must be considered in the differential diagnosis of complex kidney lesions. In this context, we reported a case of a patient investigating long-term lower back pain, in which a computed tomography (CT) showed a Bosniak IV lesion. Posteriorly, the patient was submitted to a left partial nephrectomy and the anatomo pathological study revealed a mesenchymal pattern tumor, later confirmed to be a renal leiomyoma by immunohistochemistry.

The renal leiomyoma is a benign mesenchymal tumor that originates from smooth muscle cells found in the renal capsule, renal pelvis, renal calyx and blood vessels. It is a rare neoplasm, with prevalence in autopsies ranging from 4,2% to 5,2%, representing only 1,5% of benign kidney tumors, and 0,3% of all treated kidney tumors[2].

Leiomyomas mostly affect adults, with peak incidence during the fourth decade of life, with a female-to-male ratio of 2:1. They represent approximately 0,29% of primary renal masses[2].

In most cases, leiomyomas are asymptomatic. Because of that, the diagnosis is commonly made incidentally during imaging for unrelated conditions. When symptoms are present, they include flank pain, palpable abdominal mass and hematuria.

Macroscopically, they present as firm, nodular masses that are non-capsulated and well-circumscribed, with rare calcifications or cystic features, no necrosis, frequently single and of various sizes[2]. Microscopically, the tumor resembles leiomyomas found in other soft tissue,

composed of long, fusiform cells organized in intersecting fascicles with abundant eosinophilic cytoplasm and an elongated, expressionless nucleus, with blunt ends (spindle-shaped cells)[2]. The neoplastic cells present few nuclear polymorphisms and no mitotic activity, hyperchromatism or perilesional invasiveness.

The diagnosis is made based on the histopathological analysis and confirmed by immunohisto chemistry[1], since the radiologic findings are similar to those of other renal neoplasms.

The immunohistochemistry study is positive for vimentin, smooth muscle actin, myosin, desmin, laminin and type IV collagen[2]. In contrast, tumor cells are negative for low molecular weight keratin, c-Kit and HMB45. The cell proliferation index (Ki-67) is low, which reinforces the benign nature of the neoplasm[1].

The treatment consists of surveillance or surgical resection, depending on the size, location and symptoms. It has an excellent prognosis after surgical excision.

This case is relevant because most diagnosis of leiomyoma are made in solid tumors, and in this case, the initial presentation was of a complex renal cyst, which makes the diagnosis even more challenging. It undescores the importance of clinical, radiological and histopathological correlation when evaluating renal masses.

List of Abbreviations

CT: Computed Tomography.

RENAL: Categorizes renal masses by complexity.

Ki-67: Cell proliferation index.

ACKNOWLEDGMENTS

We thank the medical team at Hospital São Vicente de Paula for the clinical support.

Conflicts of Interest: The authors declare no conflicts of interest.

REFERENCES

1. De L Schmitt FC, Cechella MS, Daudt C, Deboni LM, Bacchi CE. Leiomiossarcoma Renal. Relato de caso com estudo imuno-histoquímico. Rev Bras Cancerol. 2023; 33(1): 33–5. https://doi.org/10.3263 5/2176-9745. rbc.1987v33n1.3187
2. Karayil VR, Bhaskarashenoy M, Sukumaran G. Leiomyoma of Kidney. J Kidney Cancer VHL. 2023; 10(2): 29–32. https://doi.org/10.1558 6/jkcvhl.v10i2.264

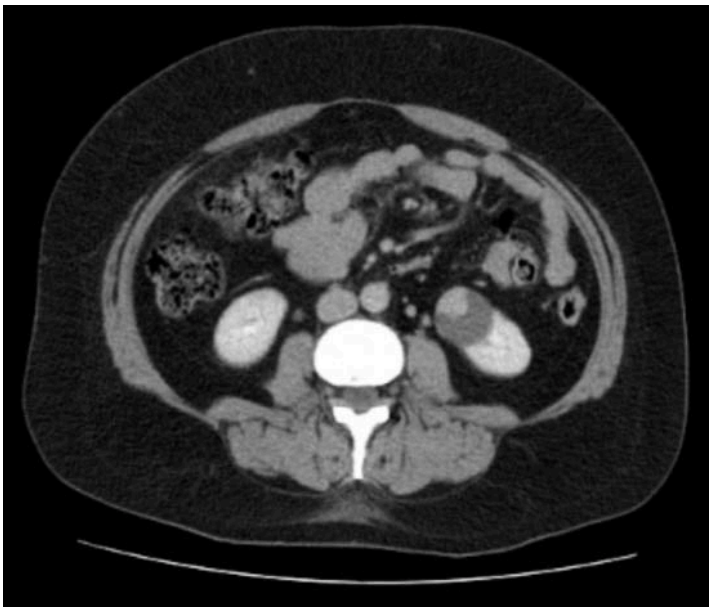


Figure 1: Axial Computed Tomography Showing a Complex Cystic Lesion Classified as Bosniak IV in the Left Kidney

Optimizing Patient Flow and Resource Utilization: Transfer Centers as Strategic Command Hubs in Multi-Hospital Healthcare Systems

Sonik Sikka

ABSTRACT

Healthcare systems face unprecedented operational challenges including capacity constraints and financial pressures, exacerbated by workforce shortages and shifting care delivery models. Optimized transfer centers emerge as a strategic solution, functioning as centralized hubs that coordinate inter- and intra- facility patient transfers while integrating clinical decision-making with logistics and bed management. This article explores how such centers serve as catalysts for enhancing access, efficiency, and cost control across a ten-hospital health system in the DMV region. Through a performance transformation framework, the article examines the structural and technological components contributing to effective transfer center operations, including centralized communication platforms, real-time data integration systems, standardized triage protocols, bed management visualization technologies, and interdisciplinary staffing models.

Keywords: healthcare operations optimization, patient transfer coordination, clinical resource utilization, healthcare system integration, operational command centers.

Classification: DDC Code: 362.11

Language: English

LJP Copyright ID: 392883

Great Britain Journals Press

London Journal of Medical & Health Research

Volume 25 | Issue 8 | Compilation 1.0

Optimizing Patient Flow and Resource Utilization: Transfer Centers as Strategic Command Hubs in Multi-Hospital Healthcare Systems

Sonik Sikka

ABSTRACT

Healthcare systems face unprecedented operational challenges including capacity constraints and financial pressures, exacerbated by workforce shortages and shifting care delivery models. Optimized transfer centers emerge as a strategic solution, functioning as centralized hubs that coordinate inter- and intra-facility patient transfers while integrating clinical decision-making with logistics and bed management. This article explores how such centers serve as catalysts for enhancing access, efficiency, and cost control across a ten-hospital health system in the DMV region. Through a performance transformation framework, the article examines the structural and technological components contributing to effective transfer center operations, including centralized communication platforms, real-time data integration systems, standardized triage protocols, bed management visualization technologies, and interdisciplinary staffing models. Key outcomes demonstrate significant improvements in transfer times, emergency department boarding, resource utilization, and financial performance. The implementation framework focuses on improving performance and lowering costs for outbound BLS ambulance and wheelchair van services for acute patient transport, while simultaneously reducing administrative burden on clinicians who were previously arranging outbound transportation and decreasing overall length of stay. Optimized transfer centers represent a high-impact intervention for healthcare systems seeking to improve resource allocation while enhancing quality and equity of care across distributed networks.

Keywords: healthcare operations optimization, patient transfer coordination, clinical resource utilization, healthcare system integration, operational command centers.

Author: MedStar Health, USA.

I. INTRODUCTION

Healthcare systems across the United States face unprecedented operational challenges, including severe capacity constraints and mounting financial pressures. Hospital occupancy rates have reached critical levels nationally, with urban facilities regularly operating at near-capacity during peak periods. This strain on resources has been exacerbated by the COVID-19 pandemic, which created unprecedented fluctuations in emergency department visit volumes and inpatient census, forcing health systems to rapidly adapt to unpredictable demand patterns. Research examining pre-pandemic and pandemic-era utilization trends demonstrated significant volatility in hospital resource needs, with some facilities experiencing dramatic surges while others faced reduced volumes and subsequent financial instability. These operational disruptions highlighted fundamental weaknesses in capacity management systems that had previously gone unaddressed during more predictable utilization patterns [1]. These constraints are compounded by widespread healthcare workforce shortages across all disciplines, creating a perfect storm of operational challenges. The projected deficits in physician and nursing staff represent not just a human resource issue but a fundamental constraint on healthcare delivery capacity at a time when demographic trends point toward increasing demand for services. Meanwhile, the healthcare economic

London Journal of Medical & Health Research

landscape has become increasingly challenging, with operating margins declining significantly for many systems post-pandemic, forcing administrators to identify operational efficiencies without compromising care quality.

Within this challenging environment, transfer centers have emerged as critical operational command centers for health systems. These centralized hubs coordinate the complex logistics of patient movement between and within healthcare facilities and transportation coordination. Modern transfer centers function as nerve centers where dedicated teams utilize integrated technology platforms to match patient needs with appropriate resources across a healthcare network. Studies examining transfer center implementation have documented improvements in key performance indicators, including reduced transfer delays, improved patient experience, and more efficient utilization of high-acuity beds. Beyond these operational metrics, effective transfer centers contribute to improved clinical outcomes by ensuring patients receive the right level of care at the right time, potentially reducing complications associated with delayed transfers or inappropriate placement [2]. The most advanced centers employ sophisticated algorithms and visualization tools to optimize patient flow, predict capacity needs, and ensure appropriate care delivery, ultimately serving as strategic assets that enhance both clinical outcomes and operational efficiency.

Despite their demonstrated value, transfer centers remain significantly underutilized across U.S. healthcare systems. Many organizations continue to rely on fragmented, decentralized transfer processes that lack standardization and technological integration. Recent analyses of healthcare operations have identified persistent barriers to transfer center adoption, including organizational silos, inadequate technological infrastructure, and resistance to standardized protocols that may appear to limit physician autonomy. This implementation gap represents a missed opportunity for health systems struggling with capacity management and cost containment in an increasingly competitive healthcare marketplace. Health systems that have successfully implemented transfer centers often report substantial improvements in network utilization efficiency, with academic medical centers better able to focus on complex cases while community hospitals maintain appropriate volumes of patients matching their capability profiles. The financial benefits extend beyond improved throughput to include reduced transport costs, decreased administrative overhead associated with transfer coordination, and optimized staffing based on more predictable patient flow patterns.

This research examines the implementation and optimization of a transfer center serving a 10-hospital health system across the District of Columbia, and Maryland region. The system encompasses a mix of academic medical centers, community hospitals, specialty facilities, and a critical access hospital, serving a diverse population across urban, suburban, and rural settings. This heterogeneous network presents distinct challenges for patient movement coordination, making it an ideal case study for examining transfer center operations in a complex healthcare environment. The study period covered multiple years of operations, during which the system implemented a phased transfer center optimization initiative, providing rich longitudinal data on performance improvements and implementation challenges. Detailed analysis of transfer patterns before and after optimization revealed significant opportunities for improved resource utilization across the network, with particular benefits for patients requiring specialized services available only at select facilities within the system.

The significance of this work extends beyond the case study organization, offering practical insights for healthcare administrators, operations leaders, and clinical teams seeking to enhance system efficiency and patient access. By developing a comprehensive framework for transfer center optimization, this research contributes to the growing field of healthcare operations management, bridging the gap between theoretical efficiency models and practical implementation strategies. The findings address a critical need for evidence-based approaches to

capacity management as healthcare systems continue to consolidate while facing increased demand and constrained resources. As value-based care models gain traction, efficient patient movement across the care continuum becomes increasingly important for both financial performance and quality outcomes. Optimized transfer centers represent a high-leverage intervention for achieving the quadruple aim of healthcare: improving patient experience, enhancing population health, reducing costs, and improving the work life of healthcare providers by reducing administrative burden and allowing focus on appropriate clinical activities.

II. METHODOLOGY AND FRAMEWORK

This study employed a comprehensive performance transformation assessment approach to evaluate and optimize transfer center operations across the ten-hospital health system. The methodology drew upon established frameworks for healthcare operations improvement, incorporating elements of Lean Six Sigma, the Institute for Healthcare Improvement's Model for Improvement, and systems engineering principles applied to healthcare delivery. The assessment began with baseline performance measurement, followed by iterative cycles of intervention design, implementation, and evaluation over a multi-year period. This longitudinal approach allowed for the identification of sustainable improvements rather than temporary gains that often regress toward baseline. The transformation framework specifically addressed four key domains: process standardization, technology enablement, workforce optimization, and governance structure. These domains were selected based on the Systems Engineering Initiative for Patient Safety (SEIPS) model, which provides a comprehensive sociotechnical systems approach to analyzing healthcare work systems and patient safety. The SEIPS framework proved particularly valuable for understanding how transfer center work processes interact with technology, organizational conditions, physical environment, and people factor to influence outcomes. By applying this model, the research team could systematically identify structural vulnerabilities in the transfer center ecosystem and target interventions that addressed root causes rather than symptoms. This systems-based approach acknowledged that successful performance transformation requires attention to both technical aspects (tools, technologies, physical layouts) and social dimensions (teamwork, communication, leadership) of the work system [3]. Each domain underwent systematic assessment and targeted intervention, with cross-domain dependencies are carefully mapped to ensure coherent improvement strategies rather than siloed initiatives that fail to deliver system-level benefits.

Data collection incorporated both quantitative and qualitative methods to develop a nuanced understanding of transfer center performance. Quantitative metrics were collected through the health system's electronic health record system, transfer center management software, and financial databases. Key performance indicators included transfer request response times, transfer denial rates, patient outcome measures following transfers, and financial metrics related to transfer operations. These data were collected at baseline and at regular intervals throughout the study period, with appropriate statistical methods applied to account for seasonal variations and other confounding factors. Qualitative data collection involved semi-structured interviews with key stakeholders, including transfer center staff, referring physicians, receiving physicians, nursing leadership, transport team members, and hospital administrators. Focus groups were conducted with clinical teams at both sending and receiving facilities to capture diverse perspectives on transfer processes. Direct observation of transfer center operations provided additional context for understanding workflow challenges and opportunities. The study employed a convergent mixed methods design, where quantitative and qualitative data were collected simultaneously, analyzed separately, and then merged during interpretation. This design was selected based on current methodological best practices that recognize the complementary strengths of different data types. The quantitative strand provided measurable outcomes and statistical validation, while the qualitative strand

offered explanatory depth and contextual understanding that numbers alone could not convey. This approach aligned with contemporary mixed methods research principles that emphasize integration throughout the research process rather than treating quantitative and qualitative components as separate studies [4]. The comprehensive data collection strategy ensured that both process measures and outcome measures were captured, enabling analysis of causal relationships between transfer center interventions and system-level performance.

The analytical framework developed for this study centered on a value stream mapping approach adapted specifically for transfer center operations. This framework decomposed the transfer process into discrete components: initial request, bed assignment, transport coordination, and post-transfer handoff. Each component was analyzed through the lens of the SEIPS model, examining work system factors (tasks, tools and technologies, organization, environment, and people) that influenced performance. Work process analysis identified barriers to smooth, efficient transfers, while outcome measures assessed both proximal operational metrics and distal patient and organizational outcomes. The framework incorporated the concept of "performance shaping factors" from human factors engineering, recognizing elements that either enhance or degrade transfer center performance. Particular attention was paid to interactions between system components, acknowledging that performance breakdowns often occur at handoff points between different teams or technologies. The analysis extended beyond the transfer center itself to examine upstream and downstream processes that impact overall patient flow. This systems perspective recognized that transfer centers operate within a complex adaptive system where changes in one area necessarily affect others. Network visualization techniques mapped patient movement patterns across facilities, identifying both formal and informal routing practices that developed in response to system constraints. The analytical approach was informed by the SEIPS model's emphasis on understanding work as performed (rather than work as imagined), using direct observation and process mapping to capture the adaptations and workarounds that emerge in complex healthcare operations [3]. This approach revealed significant gaps between documented protocols and actual practice, providing critical insights for intervention design.

Evaluation criteria for the transfer center optimization were established through consensus among key stakeholders and aligned with the health system's strategic priorities. The evaluation framework utilized a multidimensional approach that balanced competing priorities: efficiency, cost, access, clinical quality, and staff experience.

This balanced scorecard approach prevented optimization of one dimension at the expense of others-a common pitfall in healthcare improvement initiatives. Efficiency criteria encompassed time-based metrics for each transfer process component, while cost metrics addressed both direct operational expenses, and denial charges along with opportunity costs of suboptimal resource utilization. Access improvements were measured through geographic analysis of transfer origins, case-mix complexity of transferred patients, and disparity reduction in transfer acceptance rates across different patient populations. Patient outcome measures included patient experience score, length of stay.

Staff satisfaction with transfer processes was assessed through validated survey instruments. The evaluation design incorporated principles of mixed methods research, using qualitative data to explain quantitative findings and identify contextual factors that influenced outcomes. This approach allowed for both summative evaluation (did the intervention work?) and formative evaluation (how and why did it work or not work?), providing deeper insights than single-method approaches.

Several limitations affect the interpretation and generalizability of this study. First, the single health system design, while allowing for detailed analysis, limits the direct applicability of findings to systems with significantly different geographic, demographic, or organizational characteristics. Second, changes in reimbursement models and payer policies during the study period may have

influenced transfer patterns independent of the interventions studied. Third, the observational nature of the study does not permit definitive causal attribution of outcomes to specific interventions, as controlled experimentation was not ethically or operationally feasible in this clinical environment. Fourth, patient-reported outcome measures were limited by available data collection mechanisms and may not fully capture the patient experience of transfers. From a methodological perspective, the study faced challenges common to mixed methods research, including integration difficulties when quantitative and qualitative findings appeared contradictory, resource constraints that limited the depth of qualitative inquiry, and complexity in presenting integrated findings in a coherent narrative. The SEIPS model, while comprehensive, required significant adaptation to the specific context of transfer center operations, potentially limiting comparability to other applications of the framework in healthcare settings [3]. Despite these limitations, the methodological rigor applied throughout the study provides valuable insights for healthcare systems seeking to optimize transfer center operations, with appropriate contextual adaptation required for implementation in different settings.

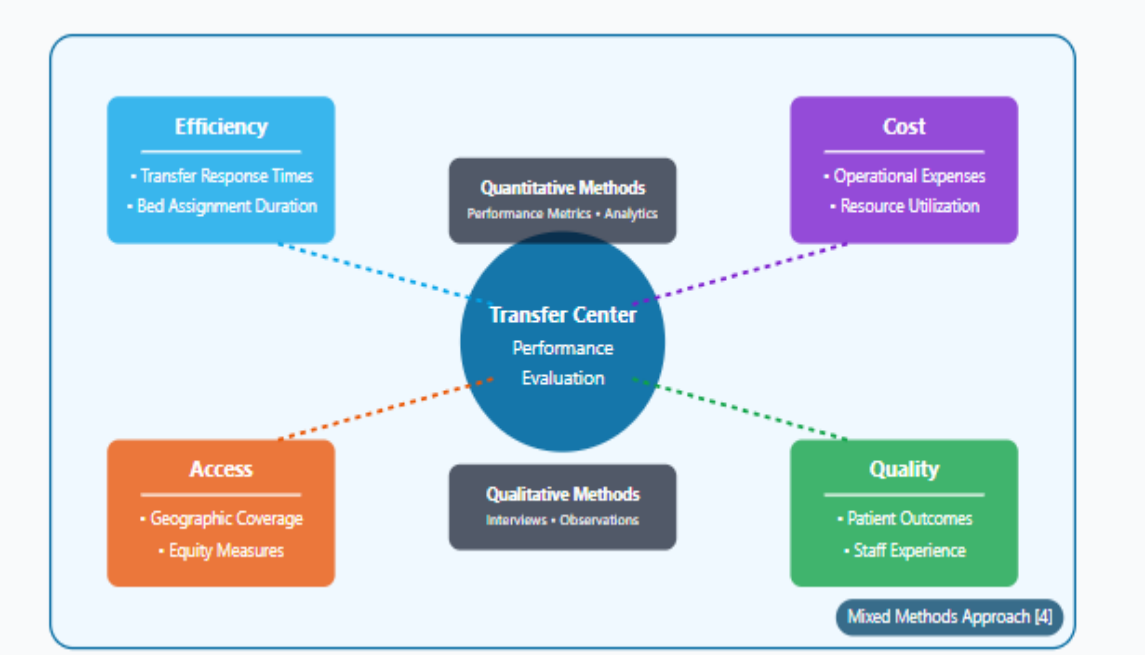


Fig. 1: Healthcare Transfer Center Performance Transformation Framework. [3, 4]

III. STRUCTURAL AND TECHNOLOGICAL COMPONENTS

The optimization of transfer center operations within the ten-hospital health system required the implementation of sophisticated structural and technological components designed to streamline communication, improve decision-making, and enhance resource utilization. At the foundation of this transformation was the deployment of complementary systems addressing different operational needs. The communication requirements were met through implementation of the Unify platform, which provided comprehensive voice and messaging capabilities. Simultaneously, the AllScripts product was deployed to address documentation and demographic needs, creating a more structured approach to transfer information management. Together, these systems replaced the fragmented approach where transfer requests were managed through separate phone lines, email systems, and paper documentation. The integrated technological ecosystem enabled simultaneous notification of all stakeholders involved in the transfer process, created a verifiable audit trail for each transfer request, and significantly reduced communication failures during handoffs. The system incorporated role-based access controls to

ensure appropriate information sharing while maintaining patient privacy. Particularly valuable was the platform's ability to support structured communication protocols modeled after the SBAR (Situation, Background, Assessment, Recommendation) framework, which standardized clinical information exchange between referring and receiving facilities. These communication frameworks have been identified as critical for reducing adverse events during care transitions, with research showing substantial reductions in information omissions when standardized protocols are implemented. Studies examining transfer center operations across integrated health networks have consistently identified communication failures as a primary driver of transfer delays, inappropriate transfers, and suboptimal resource utilization. By establishing a single, unified communication infrastructure, the health system addressed one of the most persistent root causes of transfer inefficiency. The implementation challenges encountered, including integration with legacy systems and staff adoption barriers, communication technology implementations. The phased implementation approach used in this study aligns with best practices identified in research on technology-enabled care transitions, emphasizing the importance of securing early wins by bringing one-hospital at a time and expanding additional hospital in every 4-6 weeks depending on volume and readiness by the facility [5]. The platform also incorporated dashboards displaying real-time performance metrics, enabling continuous monitoring and rapid intervention when transfer delays occurred. These dashboards utilized intuitive visualizations that highlighted bottlenecks in the transfer process, promoting accountability and supporting data-driven performance improvement initiatives across the health system.

Real-time data integration systems represented another critical technological component in the optimized transfer center model.The fragmentation of health information across disparate systems has been recognized as a significant barrier to coordinated care delivery, with particular implications for patient transfers where timely access to comprehensive information is essential for appropriate decision-making. Studies examining preventable adverse events during care transitions have highlighted incomplete information transfer as a contributing factor in a substantial proportion of cases. By creating a unified data environment that consolidates relevant information from multiple sources, the transfer center implementation addressed a fundamental vulnerability in the care transition process. The emphasis on user experience design within the data integration system aligns with the principles articulated in research on human factors in healthcare technology, which emphasizes that technological solutions must be designed to support rather than complicate clinical workflows [6]. The data integration architecture was designed with redundant connectivity and fault-tolerant components to ensure system availability during network outages or electronic health record downtime, acknowledging the critical nature of transfer center operations in maintaining patient flow across the health system.

Standardized triage protocols and decision support tools fundamentally transformed the clinical assessment process for patient transfers within the health system. These protocols replaced variable, provider-dependent appro-aches with evidence-based algorithms that ensured consistent evaluation of transfer appropriateness, acuity level, and destination selection. The triage system incorporated condition-specific protocols for high-volume transfer scenarios such as stroke, trauma, acute coronary syndrome, and high-risk obstetrics, with embedded clinical criteria drawn from national guidelines and institutional standards of care. Each protocol guided transfer coordinators through a structured assessment process, ensuring comprehensive collection of relevant clinical data and standardized risk stratification. The decision support tools integrated with these protocols provided real-time recommendations for transfer destination based on patient needs, facility capabilities, geographic proximity, and current capacity. The implementation of standardized triage protocols addresses the

unwarranted clinical variation documented in studies of transfer processes, where similar patients with similar conditions often receive dramatically different transfer decisions depending on individual provider practices. This variation has been associated with inefficient resource utilization, unnecessary transfers to higher levels of care, and delayed access for patients who truly need specialized services. Research on clinical decision support systems in emergency and acute care settings has demonstrated improvements in protocol adherence, reduced time to appropriate intervention, and decreased resource utilization when evidence-based algorithms are effectively integrated into clinical workflows. The challenges encountered in implementing these protocols, particularly regarding physician consensus and concerns about clinical autonomy, echo findings from implementation science research on evidence-based protocols in complex healthcare environments. The successful approach of inclusive protocol development, clear override mechanisms, and continuous performance review aligns with recommended strategies for balancing standardization with appropriate clinical flexibility. The incorporation of continuous learning mechanisms to refine algorithm performance represents an application of the learning healthcare system model, where data on actual outcomes systematically informs improvements in care processes [5]. The resulting triage system significantly reduced inappropriate transfers, minimized delays for time-sensitive conditions, and improved resource matching across the health system.

Bed management and capacity visualization technologies provided unprecedented transparency regarding resource availability throughout the healthcare network. The challenge of coordinating patient placement across a distributed healthcare network represents a complex system problem where traditional approaches to information management are inadequate. When transfer decisions are made without comprehensive visibility into system-wide resources, suboptimal patterns emerge: patients may be transferred to facilities that are already at capacity while available beds at equally appropriate facilities remain unused; transport resources may be deployed inefficiently; and delays in care may result from the time-consuming process of sequential inquiries about bed availability. Studies examining preventable adverse events in emergency departments and critical care units have identified capacity constraints and patient flow disruptions as contributing factors in patient harm events. The implementation of transparent, real-time capacity visualization directly addresses these system vulnerabilities by enabling more informed, rapid decision-making about patient placement. The capacity visualization technology implemented in this study builds upon concepts from high-reliability organizations in other industries, where shared situational awareness among all participants is recognized as essential for safe and efficient operations in complex, dynamic environments [6]. The resulting transparency enabled more equitable distribution of patients throughout the system, reducing bottlenecks at tertiary centers while appropriately utilizing community hospital capacity.

Staffing models and interdisciplinary team composition evolved significantly as part of the transfer center optimization. The enhanced model moved beyond traditional nurse or provider led transfer coordination to establish a truly interdisciplinary approach that included physicians, nurses, advanced practice providers, bed managers, transport coordinators, and administrative personnel working collaboratively within a unified operational structure. This team-based model provided comprehensive coverage across all clinical domains and operational functions involved in the transfer process. A key innovation was the implementation of physician-directed triage for complex or high-acuity transfers, where specialized physicians provided real-time clinical consultation to both referring providers and transfer center staff. This capability enhanced clinical decision-making while simultaneously reducing inappropriate transfers and optimizing destination selection. The staffing model incorporated tiered response protocols that

adjusted team composition based on transfer volume, acuity, and complexity, ensuring efficient resource utilization during both routine operations and surge events. The evolution toward interdisciplinary staffing models reflects growing recognition in healthcare operations research that complex care coordination functions require diverse expertise beyond traditional disciplinary boundaries. Studies of high-performing transfer centers have identified interdisciplinary staffing as a key differentiator between basic coordination functions and true system optimization. The inclusion of physician leadership within the transfer center model addresses limitations documented in research on nurse-led transfer coordination, where the absence of real-time physician consultation can result in decision delays, unnecessary transfers, or inappropriate destination selection. The challenges encountered in implementing interdisciplinary staffing, particularly regarding role delineation and sustainable physician coverage, are consistent with findings from research on team-based care models in other healthcare contexts. The approaches used to address these challenges-detailed workflow analysis, workload-based staffing algorithms, and innovative compensation models—align with strategies recommended in the literature on healthcare workforce optimization. The performance improvement observed following implementation of the interdisciplinary model supports broader research findings on the value of team-based approaches for complex healthcare operations [5]. The resulting interdisciplinary team structure created a high-reliability organization capable of managing complex patient transfers consistently and effectively across the health system.

Table 1: Core Structural and Technological Components of the Optimized Transfer Center [5, 6]

Component	Key Features	Operational Impact	Implementation Challenges
Centralized Communication Platform	• Unified interface for voice, messaging, and documentation • SBAR-structured protocols • Role-based access controls • Performance dashboards	• Reduced communication failures • Complete audit trails • Decreased coordination time • Improved stakeholder notification	• Integration with legacy systems • Standardization across diverse clinical environments • Staff adoption • Change management
Standardized Triage Protocols	• Condition-specific algorithms • "Best-match" destination selection • Evidence-based decision support • Override mechanisms	• Consistent assessment • Reduced inappropriate transfers • Optimized resource matching • Expedited time-sensitive transfers	• Achieving physician consensus • Balancing standardization with clinical judgment • Protocol validation • Continuous refinement
Capacity Visualization Technologies	• Multi-dimensional capacity display • Geospatial integration	• Enhanced resource transparency • Balanced network utilization • Reduced bottlenecks • More equitable patient distribution	• Ensuring data currency • Standardizing capacity definitions • Managing information overload • Refresh rate optimization

Interdisciplinary Staffing Model	• Physician-directed triage • Integrated transport coordination • Tiered response protocols • Cross-training programs	• Enhanced clinical decision-making • Comprehensive transfer management • Operational resilience • Efficient resource utilization	• Role delineation • Sustainable physician coverage • Staffing ratio determination • Team integration

IV. OPERATIONAL AND FINANCIAL IMPACT

The implementation of an optimized transfer center yielded substantial operational improvements across the ten-hospital health system, most notably in transfer time reduction and enhanced throughput metrics. Prior to optimization, the mean time from transfer request to acceptance decision was lengthy, with significant variability based on time of day, day of week, and receiving facility. Following implementation of the standardized communication platform and triage protocols, this interval decreased considerably, with further reductions for time-sensitive clinical conditions such as stroke, acute coronary syndrome, and trauma. The time from acceptance to arrival at the receiving facility similarly improved, driven by more efficient transport coordination. These time reductions translated directly to clinical benefits, particularly for time-sensitive conditions where treatment delays correlate with adverse outcomes. For stroke transfers, the proportion of patients receiving appropriate reperfusion therapy within recommended timeframes increased significantly, while for acute coronary syndrome, the percentage of patients achieving guideline-recommended door-to-balloon times improved across the system. Beyond these high-acuity scenarios, throughput improvements were observed across all transfer categories, with the health system able to accommodate an increased transfer volume without corresponding increases in staffing or infrastructure. The most dramatic improvements occurred for inter-facility transfers within the health system, where standardized protocols and consolidated communication channels eliminated redundant steps and reduced coordination overhead. Notably, these improvements were sustained over the study period despite fluctuations in patient volume and acuity, suggesting that structural changes rather than temporary process improvements were responsible for the enhanced performance. These findings align with research on healthcare coordination networks, which has demonstrated that formalized, centralized transfer systems with standardized protocols can significantly improve patient flow across distributed healthcare systems. Studies examining regional trauma systems and stroke networks have similarly documented substantial improvements in time-to-treatment metrics following implementation of coordinated transfer protocols. The patient flow optimization achieved through the transfer center demonstrates the practical application of queueing theory principles to healthcare operations, where reducing artificial variability and streamlining handoff processes can dramatically improve system throughput without additional resource investment. The networked structure of the optimized transfer center enabled the health system to function more effectively as an integrated delivery system rather than a collection of independent facilities, aligning with contemporary perspectives on regional healthcare coordination as described in the literature on accountable health communities and integrated delivery networks [7]. The throughput enhancements directly supported the health system's strategic objectives of improving access to appropriate levels of care while maximizing operational efficiency across the network.

Emergency department (ED) boarding and inpatient length of stay metrics demonstrated noteworthy improvements following transfer center optimization. ED boarding-defined as the time patients remain in the emergency department after the decision to admit or

transfer-decreased substantially across the health system. This reduction was particularly pronounced at community hospitals that previously experienced extended boarding times for patients awaiting transfer to higher levels of care. The optimized transfer center directly addressed key drivers of boarding, including delayed transfer acceptance decisions, inefficient bed assignment processes, and suboptimal transport coordination. The implementation of capacity visualization and standardized triage protocols enabled more rapid identification of appropriate receiving units, while the interdisciplinary staffing model facilitated expedited clinical decision-making. Beyond the operational benefits, reduced boarding times correlated with improvements in patient satisfaction metrics and decreased incidents of care delays or complications associated with prolonged ED stays. Length of stay outcomes similarly improved across the health system, with transferred patients experiencing reduced total hospitalization duration when compared to risk-adjusted expectations. This improvement appeared to result from several factors: more appropriate initial placement reducing the need for subsequent intra-system transfers; earlier initiation of specialized care pathways following more efficient transfers; and more effective matching of patient needs with facility capabilities. Particularly notable was the reduction in "avoidable days"—inpatient days where patients remained hospitalized despite no longer requiring the current level of care—which decreased significantly following implementation of the optimized transfer system. The health system also observed a reduction in transfer denials and denials or bills from ambulance vendors due to reported capacity constraints, and payor mismatch suggesting more efficient utilization of available resources. These improvements in ED boarding and length of stay metrics align with findings from research on hospital operations management, which has identified care transitions as critical junctures where inefficiencies frequently accumulate. Studies examining the economic impact of healthcare quality have demonstrated that improvements in patient flow metrics can generate substantial cost savings while simultaneously enhancing clinical outcomes and patient experience. The reduced ED boarding times achieved through transfer center optimization address a well-documented patient safety concern, as prolonged ED boarding has been associated with adverse events, delayed treatment initiation, and increased mortality in multiple studies. By improving this key operational metric, the transfer center optimization directly contributed to both financial performance improvement and enhanced clinical quality, exemplifying the concept of the "triple aim" in healthcare improvement where better care and lower costs can be achieved simultaneously [8]. The consistent improvements observed across diverse facilities within the health system suggest that the transfer center optimization provided structural benefits that transcended individual institutional factors.

Transport resource optimization occurred through several mechanisms: reduced redundant or unnecessary transports through improved initial triage and destination selection; more efficient dispatch and routing through centralized coordination; decreased transport team idle time through improved scheduling; and reduced upgrade/downgrade decisions regarding transport modality. The health system observed a substantial reduction in advanced life support transports for patients who ultimately did not require that level of care during transport, representing both a cost saving and a more appropriate allocation of limited specialized transport resources. The optimization extended beyond critical care to include appropriate utilization of specialized units such as intermediate care, telemetry, and specialty-specific beds. By implementing systematic matching of patient needs with the appropriate level of care, the transfer center reduced instances of both over-triage (placing patients in higher levels of care than clinically necessary) and under-triage (placing patients in lower levels of care than their condition warranted). These improvements in resource allocation efficiency reflect principles described in research on healthcare network optimization, where coordinated, system-level approaches to resource

compared to facility-level optimization efforts. Studies examining regional healthcare networks have demonstrated that suboptimal patient distribution often results from information asymmetry and coordination barriers rather than actual resource constraints. The centralized visibility and standardized coordination provided by the optimized transfer center directly addressed these structural limitations, enabling more effective resource utilization across the distributed healthcare network. The "network effect" benefits achieved through this system-level approach align with theoretical models of healthcare delivery that emphasize the importance of coordination mechanisms in complex adaptive systems [7]. The optimization of both bed and transport resources supported the health system's ability to maintain appropriate access during periods of peak demand while improving overall operational efficiency.

Cost-benefit analysis of the transfer center implementation demonstrated compelling financial returns alongside the clinical and operational improvements. The financial model incorporated multiple cost and revenue components, including direct operational costs, indirect infrastructure costs, opportunity costs, and revenue implications. Direct costs included staffing, technology, facilities, and ongoing maintenance expenses associated with the transfer center. Indirect costs encompassed training, change management, and temporary productivity losses during implementation. These implementation costs were substantial, requiring significant capital investment and ongoing operational funding. However, the financial benefits substantially outweighed these costs when analyzed over a multi-year period. Revenue enhancements occurred through several mechanisms: increased appropriate transfers into the system from external facilities; reduced transfer denials due to capacity constraints; improved retention of appropriate patients within the network; fewer instances where the transfer center has to cover the cost for patient transport and optimized patient placement resulting in more appropriate reimbursement. Cost savings were achieved through multiple pathways: reduced unnecessary transfers and associated transport costs; decreased length of stay and avoidable days; reduced administrative overhead for transfer coordination; lower overtime and agency staffing needs due to improved predictability; and decreased adverse events associated with transfer delays or inappropriate placements. The return on investment calculation demonstrated a positive financial return beginning in the early phase of operation, with increasing returns in subsequent years as optimization efforts matured. These financial outcomes align with research on the economics of healthcare quality, which has documented the significant costs associated with inefficient care processes, medical errors, and suboptimal resource utilization. Studies examining the financial impact of quality improvement initiatives have consistently found that interventions targeting systemic inefficiencies often generate positive returns on investment, particularly when they address high-cost adverse events or resource misalignment. The transfer center optimization exemplifies the concept of "quality-related cost savings" described in healthcare economics literature, where improvements in operational processes simultaneously enhance quality and reduce costs.

By addressing inefficiencies in the transfer process, the optimization initiative generated cost savings through multiple mechanisms while also improving clinical outcomes and patient experience. The positive financial performance observed in this implementation supports the business case for quality improvement in healthcare operations, countering the perception that clinical quality enhancements necessarily increase costs [8]. The positive financial impact supported ongoing investment in transfer center enhancements while demonstrating that clinical quality improvement and financial performance improvement could be achieved simultaneously through systematic optimization of patient flow.

Table 2: Key Operational and Financial Outcomes Following Transfer Center Optimization [7, 8]

Outcome Domain	Pre-Optimization Baseline	Post-Optimization Results	Impact Analysis
Transfer Process Efficiency	• Extended decision times • Variable coordination processes • Limited tracking capabilities	• Significantly reduced request-to-acceptance times • Streamlined coordination • Comprehensive performance tracking	• Improved time-sensitive clinical outcomes • Enhanced provider and patient satisfaction • Increased system capacity without infras- tructure expansion
Emergency Department Impact	• Prolonged boarding times • Transfer delays • Resource misalignment	• Considerable boarding reduction • Expedited transfers • Improved resource matching	• Decreased adverse events associated with boarding • Improved ED throughput • Enhanced capacity for new ED arrivals
Resource Utilization	• Tertiary center overcrowding • Administrative burden on clinicians to arrange transpor- tation • Mismatched transport resources	• Balanced distribution across network • Clinicians working at top of their licensure • Optimized transport allocation	• "Virtual capacity" creation • Reduced staff burnout in high-volume centers • More appropriate level-of-care placement
Financial Performance	• High transfer-related administrative costs • Lost revenue from inappropriate transfers • Inefficient resource deployment	• Reduced administrative overhead • Improved appropriate transfer retention • Optimized resource allocation	• Positive ROI achieved • Enhanced contribution margin • Sustainable operational model

V. IMPLEMENTATION FRAMEWORK

Successful implementation of an optimized transfer center requires a robust governance structure and comprehensive stakeholder engagement strategy. The governance model developed for this health system established a multi-tiered structure with clearly defined roles and responsibilities. At the executive level, a Transfer Center Steering Committee comprised senior leadership from each facility, including chief medical officers, and operational executives. This committee established strategic priorities, approved resource allocation, resolved cross-facility conflicts, and maintained alignment with broader health system objectives. At the operational level, a Transfer Center Operations Council included physician leaders from key service lines (emergency medicine, critical care, hospital medicine), nursing leadership, bed management directors, transport services representatives, and information technology specialists. This council managed day-to-day implementation decisions, protocol development, and performance monitoring. A third tier consisted of facility-specific implementation teams responsible for local training, workflow adaptation, and change management. This multi-level governance approach ensured both system-wide standardization and appropriate local customization. Stakeholder engagement extended beyond formal governance structures to include comprehensive involvement of frontline clinicians and staff. Recognizing that transfer

center success depends on clinician adoption, the implementation team conducted extensive engagement activities, including focus groups with referring and receiving physicians, simulation exercises with case managers, social workers, and incorporating feedback. The technology integration roadmap represented a critical component of the implementation framework, guiding the complex process of deploying and connecting multiple technical systems across the distributed health network. The roadmap followed a phased approach, beginning with a comprehensive assessment of existing technologies, identification of integration requirements, and gap analysis comparing current capabilities to the desired future state. This assessment revealed legacy and discrete telecommunication infrastructure and documentation flow. The implementation sequence prioritized foundational components first: the centralized communication platform, unified transfer request documentation system, and basic bed status visualization. This phase established the core infrastructure while delivering early operational benefits.. A parallel telecommunications upgrade ensured reliable connectivity and call management capabilities across all facilities. The technology roadmap incorporated multiple safeguards to maintain operational continuity during implementation, including overlapping systems during transition periods, comprehensive contingency protocols, and phased cutover strategies that minimized disruption to clinical operations. The phased implementation approach employed in the technology roadmap reflects best practices identified in research on large-scale organizational change initiatives. Studies examining why transformation efforts fail have consistently identified overly aggressive timelines and inadequate attention to infrastructure requirements as common failure modes. The sequential implementation strategy, with foundational capabilities deployed before more advanced features, aligns with the principle of establishing "short-term wins" that build momentum and credibility for the broader transformation. The careful attention to operational continuity during technology transitions addresses a critical risk factor identified in healthcare transformation research: the potential for implementation activities to disrupt essential clinical operations. The comprehensive testing protocols and overlapping system approach exemplify the "risk mitigation" strategies recommended for complex healthcare technology implementations, where patient safety considerations necessitate extraordinarily high reliability during transition periods. The roadmap's balance between strategic vision and tactical implementation details demonstrates the "dual operating system" approach advocated in contemporary change management literature, where transformational initiatives require both clear long-term direction and detailed near-term execution planning [10]. The technology roadmap provided clear direction while maintaining flexibility to adapt to emerging requirements and technical challenges, supporting successful deployment across the diverse health system environment.

Performance monitoring and continuous improvement formed the backbone of the implementation framework, establishing mechanisms to track progress, identify opportunities, and drive ongoing optimization. The performance monitoring system incorporated three distinct measurement categories: process metrics that assessed the efficiency and reliability of transfer center operations; outcome metrics that evaluated the impact on patient care and system performance; and balancing metrics that monitored for unintended consequences. Key process indicators included transfer request response times, protocol adherence rates, and documentation completeness. Outcome measures encompassed length of stay impacts, and resource utilization patterns. Balancing metrics monitored for potential negative effects such as inappropriate transfer denials, long wait times, ambulance transport expense denied due to lack of medical necessity or insurance verification, staff workload concerns, or unintended shifts in patient distribution. The measurement framework established clear definitions, data sources, calculation methodologies, and reporting frequencies for each metric, ensuring consistent

evaluation across facilities and time periods. A tiered reporting structure delivered tailored information to different stakeholders: detailed operational metrics for transfer center staff; service-line and facility-specific indicators for clinical and operational leaders; and summary performance dashboards for executive leadership. Beyond mere measurement, the continuous improvement model established structured processes for acting on performance data. Daily huddles reviewed immediate operational issues, while weekly improvement teams addressed emerging patterns, and monthly governance meetings evaluated systemic challenges. The model employed standard improvement methodologies, including Plan-Do-Study-Act cycles for rapid testing of interventions and more comprehensive project management approaches for complex initiatives. Particularly effective was the implementation of regular case reviews for transfers that failed to meet performance targets, creating opportunities for process learning rather than individual blame. The comprehensive approach to performance monitoring implemented in the transfer center aligns with the self-management support and decision support elements of the Chronic Care Model as applied to complex healthcare operations. The original model has been expanded in recent years to emphasize the importance of robust measurement systems not just for individual patient care but for system-level performance improvement. Research examining successful clinical integration initiatives has identified transparent performance monitoring as a critical enabler of sustained improvement, creating what has been termed a "learning healthcare system" where operational data continuously informs system refinement. The balanced measurement approach-incorporating process, outcome, and balancing metrics-reflects contemporary understanding of healthcare quality measurement, which emphasizes the importance of multidimensional evaluation to avoid optimization of isolated metrics at the expense of overall system performance. The tiered reporting structure, with different views for different stakeholders, demonstrates application of the "prepared, proactive team" concept from the Chronic Care Model to the operational domain, where each team member receives information relevant to their role in the overall system [9]. The performance system created a data-driven culture that supported continuous optimization beyond the initial implementation period.

Change management strategies represented a critical success factor in the transfer center implementation, acknowledging that the initiative required significant modifications to established workflows, communication patterns, and decision-making processes across multiple facilities and clinical departments. The change management approach began with a comprehensive stakeholder analysis that identified key influencers, potential sources of resistance, and existing cultural factors at each facility. This analysis informed the development of tailored engagement strategies that addressed the specific concerns and motivations of different stakeholder groups. For physicians, the emphasis was on clinical benefits and reduced administrative burden; for case managers, social workers, improved patient flow and appropriate resource utilization; for administrators, enhanced efficiency and financial performance. A network of change champions was established at each facility, comprised of respected clinical leaders who served as local advocates and provided bidirectional communication between implementation teams and frontline staff. The communication strategy employed multiple modalities to reach diverse audiences, including executive briefings, department-specific presentations, and regular implementation updates through existing communication channels. Particularly effective was the use of specific patient stories and case examples that illustrated the concrete benefits of the optimized transfer process. The change management plan explicitly addressed anticipated barriers, including concerns about loss of autonomy in transfer decisions, unfamiliarity with new technologies, and skepticism about standardized protocols. These concerns were mitigated through focused education, early involvement in protocol development, and transparent sharing of performance data that demonstrated tangible

improvements. The change management approach employed in the transfer center implementation exemplifies several key principles from established change management frameworks. The structured eight-step process for leading change has been widely validated across industries, with particular relevance to healthcare transformation initiatives. The implementation team's emphasis on creating a sense of urgency through compelling clinical and operational rationales aligns with the first step in this process, while the multi-level governance structure established the "guiding coalition" essential for leading complex change. The clear articulation of the future vision for transfer center operations, coupled with concrete examples of how this vision would improve patient care and provider experience, addressed the critical steps of developing and communicating a change vision.

The phased implementation approach, with early wins deliberately highlighted through performance dashboards and success stories, exemplifies the principle of generating short-term wins to build momentum and overcome skepticism. The systematic approach to addressing resistance—through engagement, education, and demonstrated benefits—reflects contemporary understanding of change management as requiring both emotional and rational elements to overcome the natural human tendency to resist disruption of established patterns [10]. The effectiveness of these strategies was evidenced by high adoption rates and sustained performance improvements across all facilities in the health system.

Scalability considerations formed an essential component of the implementation framework, ensuring that the transfer center model could accommodate varying health system sizes, configurations, and growth patterns. Staffing models were developed with scalability in mind, establishing baseline requirements for different transfer volumes and complexity levels, with clear guidance for adjusting resources as demands evolved. Similarly, technology solutions were selected with attention to scaling capabilities, including licensing models that accommodated growth, technical architectures that supported increased transaction volumes, and integration approaches that could incorporate additional facilities or external partners. The governance structure incorporated mechanisms for expanding oversight as the system grew, with representation models that maintained appropriate stakeholder involvement despite increasing organizational complexity. Particularly important was designing the transfer center to support different facility types, from academic medical centers with specialized service lines to community hospitals with more general capabilities. The protocols and workflows accommodated these variations while maintaining standardization in core processes. A tiered service model was established, where facilities could implement different levels of transfer center integration based on their size, capabilities, and strategic priorities. Small facilities with limited resources could leverage basic transfer coordination services, while larger institutions could implement the full suite of advanced capabilities. This flexible approach supported both current variation across the health system and future evolution as facilities developed new service lines or modified their strategic focus. The scalability considerations integrated into the transfer center design reflect principles from the expanded Chronic Care Model, which emphasizes the importance of creating systems that can function effectively across different organizational contexts and scales. Research on clinical integration initiatives has identified scalability as a critical factor in sustainability, with many otherwise successful pilots failing to achieve widespread adoption due to design elements that could not be effectively translated to different settings or larger scales. The tiered service model, with different levels of transfer center implementation based on facility characteristics, aligns with contemporary understanding of healthcare network development, which recognizes the importance of matching capabilities to local needs while maintaining network-level coordination [9]. The attention to scalability ensured that the transfer center implementation represented a sustainable investment that could evolve alongside the health system rather than requiring replacement as organizational needs changed.

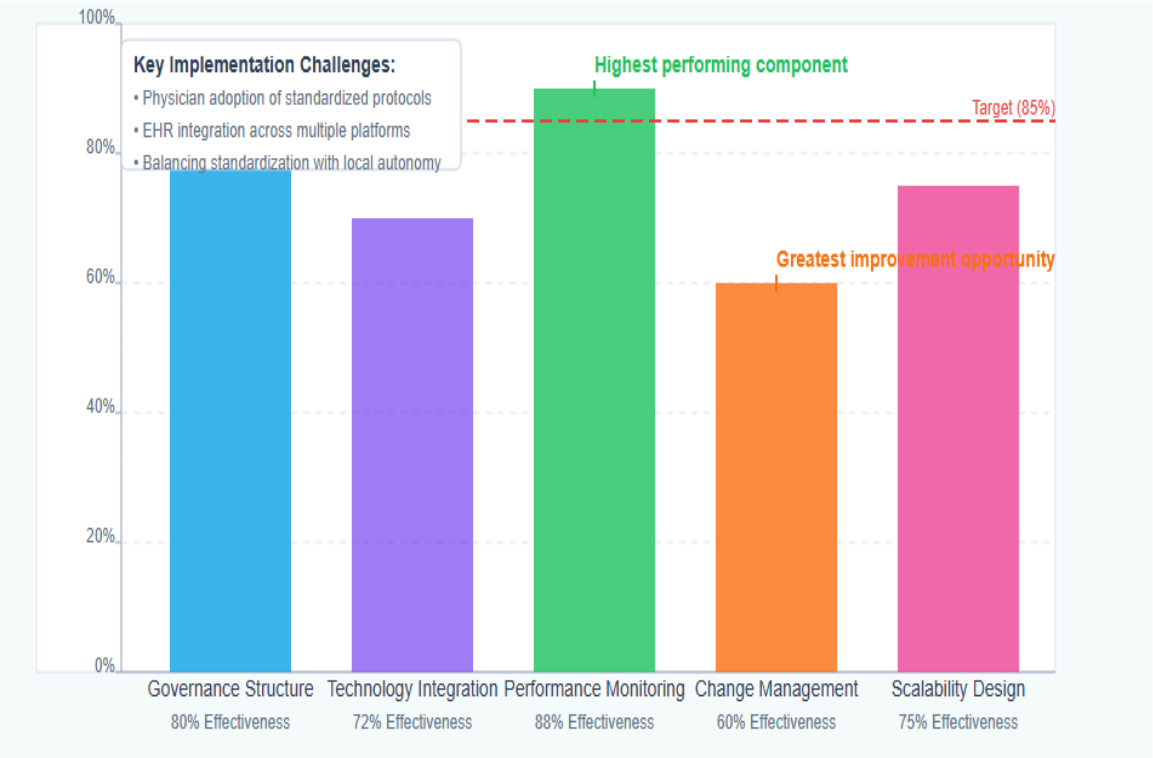


Fig. 2: Transfer Center Implementation Framework: Critical Success Factors. [9, 10]

VI. CONCLUSION

Optimized transfer centers represent a transformative intervention for healthcare systems facing capacity constraints and financial pressures. The implementation across the ten-hospital system demonstrated substantial improvements in operational efficiency, resource utilization, and financial performance. The multi-faceted approach—combining centralized communication, real-time data integration, standardized protocols, visualization technologies, and interdisciplinary staffing—created structural changes that yielded sustainable benefits transcending individual facilities. The implementation framework, with its emphasis on governance, technology integration, performance monitoring, change management, and scalability, provides a blueprint adaptable to various healthcare environments. As consolidation continues across the healthcare landscape and demand increases for specialized services, transfer centers offer a scalable solution for achieving the quadruple aim: improving patient experience, enhancing population health while reducing costs, and supporting healthcare providers. The success of this initiative demonstrates that operational excellence and clinical quality can be simultaneously achieved through systematic optimization of patient flow across healthcare networks.

REFERENCES

1. Savaş SEZİK et al., "Trends in Emergency Department Visits, and Hospital Admissions Pre- and During Covid-19Pandemic," ResearchGate, 2023. https://www.researchgate.net/publication/374594315_Trends_in_Emergency_Department_Visits_and_Hospital_Admissions_Pre-_and_During_Covid_19_Pandemic
2. Karima Lalani et al., "The Impact of COVID-19 on the Financial Performance of Largest Teaching Hospitals," Healthcare (Basel). 2023. https://pmc.ncbi.nlm.nih.gov/articles/PMC10379302/
3. Richard J Holden et al., "SEIPS 2.0: a human factors framework for studying and improving the work of healthcare professionals and patients," Ergonomics. 2013. https://pubmed.ncbi.nlm.nih.gov/24088063/
4. Priscilla Robinson, "Designing and Conducting Mixed Methods Research,"

Research Gate, 2007. https://www.researchgate.net/publication/369555560_Designing_and_Conducting_Mixed_Methods_Research
5. Sultanah Al Harbi et al., "Streamlining patient flow and enhancing operational efficiency through case management implementation," BMJ Open Qual. 2024. https://pmc.ncbi.nlm.nih.gov/articles/PMC10910643/
6. Linda T. Kohn et al., "To Err is Human," National Academies Press (US); 2000. https://www.ncbi.nlm.nih.gov/books/NBK225182/
7. Nass SJ, et al., "Ending Unequal Treatment: Strategies to Achieve Equitable Health Care and Optimal Health for All." National Academies Press (US); 2024. https://www.ncbi.nlm.nih.gov/books/NBK607582/
8. Charles Andel et al., "The economics of health care quality and medical errors," Research Gate, 2012. https://www.researchgate.net/publication/233533297_The_economics_of_health_care_quality_and_medical_errors
9. Edward H. Wagner, "Organizing Care for Patients With Chronic Illness Revisited," ResearchGate, 2019. https://www.researchgate.net/publication/335249670_Organizing_Care_for_Patients_With_Chronic_Illness_Revisited
10. John P Kotter, "Leading Change: Why Transformation Efforts Fail," ResearchGate, 2007. https://www.researchgate.net/publication/246663143_Leading_Change_Why_Transformation_Efforts_Fail

This page is intentionally left blank

A Vascular Benign Lesion in a Perilous Location

Hajer Kammoun

ABSTRACT

Background: Hemangioblastomas are highly vascular grade 1 tumors arising sporadically or, more rarely, in the context of Von Hippel-Lindau disease. Cystic brainstem hemangioblastomas are rare with only few cases reported in literature.

Even though they are benign, their surgery is challenging in view of their eloquent location and vascularity. Thorough perioperative manage- ment is required.

Case presentation: We report the case of a 47-year-old female patient with progressive weakness, difficulty in swallowing and ataxic gait. The brain MRI showed a cystic lesion occupying the caudal part of the fourth ventricle and the dorsal medulla oblangata. We performed a subtotal excision of the tumor that was challenging due to its adherence to the floor of the 4th ventricle and its high vascularity. The pathology exam concluded to a hemangio- blastoma.

Keywords: hemangioblastoma, brainstem, surgery, case-report.

Classification: NLM Code: WL 358

Language: English

Great Britain Journals Press

London Journal of Medical & Health Research

Volume 25 | Issue 8 | Compilation 1.0

A Vascular Benign Lesion in a Perilous Location

Hajer Kammoun

ABSTRACT

Background: Hemangioblastomas are highly vascular grade 1 tumors arising sporadically or, more rarely, in the context of Von Hippel-Lindau disease. Cystic brainstem hemangioblastomas are rare with only few cases reported in literature.

Even though they are benign, their surgery is challenging in view of their eloquent location and vascularity. Thorough perioperative management is required.

Case presentation: We report the case of a 47-year-old female patient with progressive weakness, difficulty in swallowing and ataxic gait. The brain MRI showed a cystic lesion occupying the caudal part of the fourth ventricle and the dorsal medulla oblangata. We performed a subtotal excision of the tumor that was challenging due to its adherence to the floor of the 4th ventricle and its high vascularity. The pathology exam concluded to a hemangioblastoma.

The patient presented a good evolution with no tumor progression in 6 months follow-up.

Clinical discussion: The cystic brainstem hemangioblastoma is a rare seemingly innocuous lesion but highly challenging to neurosurgeons. MRI is the investigation of choice, regularly sufficient for preoperative evaluation. Still, some authors recommend the performance of a cerebral angiography or a CTA preoperatively.

In literature, many strategies, such as the use of preoperative embolization or radiosurgery were described, aiming for a better-quality surgery and prognosis.

Conclusion: Cystic brainstem hemangioblastoma is a scarce histologically benign but challenging lesion with surgical difficulties. Through our case and literature review, we concluded that surgery is the mainstay treatment for brainstem hemangioblastomas mainly cystic ones and that a thorough study of its vascularization via angiography or CTA with a preoperative tumor embolization can help achieve a total tumor resection with good functional outcome and low mortality.

Keywords: hemangioblastoma, brainstem, surgery, case-report.

I. INTRODUCTION AND IMPORTANCE

Hemangioblastomas are highly vascular OMS grade 1 tumors that arise both sporadically (75%) and, more rarely (25%), in the context of Von Hippel-Lindau disease (1). Only 5-20% are located in the brainstem, among them cystic hemangioblastomas are scarcer with only few cases reported in literature.

They present a unique challenge in view of their eloquent location and vascularity. Significant neurological improvement is though achievable. Thorough perioperative management is required as well as the treatment of potential associated abdominal masses.

II. CASE-REPORT

It's about a 47-year-old female patient who was presenting progressive weakness, difficulty in swallowing and ataxic gait of six months duration. There were no focal motor or sensory deficits. Her blood investigations were normal. The brain MRI showed a cystic lesion occupying the caudal part of the fourth ventricle and the dorsal medulla oblangata (Fig.1). We performed a midline suboccipital craniectomy in prone position, with C1 laminectomy. Under an operating microscope, a Y-shaped durotomy was performed, arachnoidal membrane opened, exposing the tumor which was shrunk by coagulation under copious irrigation.

Subtotal excision of the tumor was performed limited by its adherence to the floor of the 4th

ventricle and its high vascularity. The pathology exam concluded to a hemangioblastoma (Fig. 2).

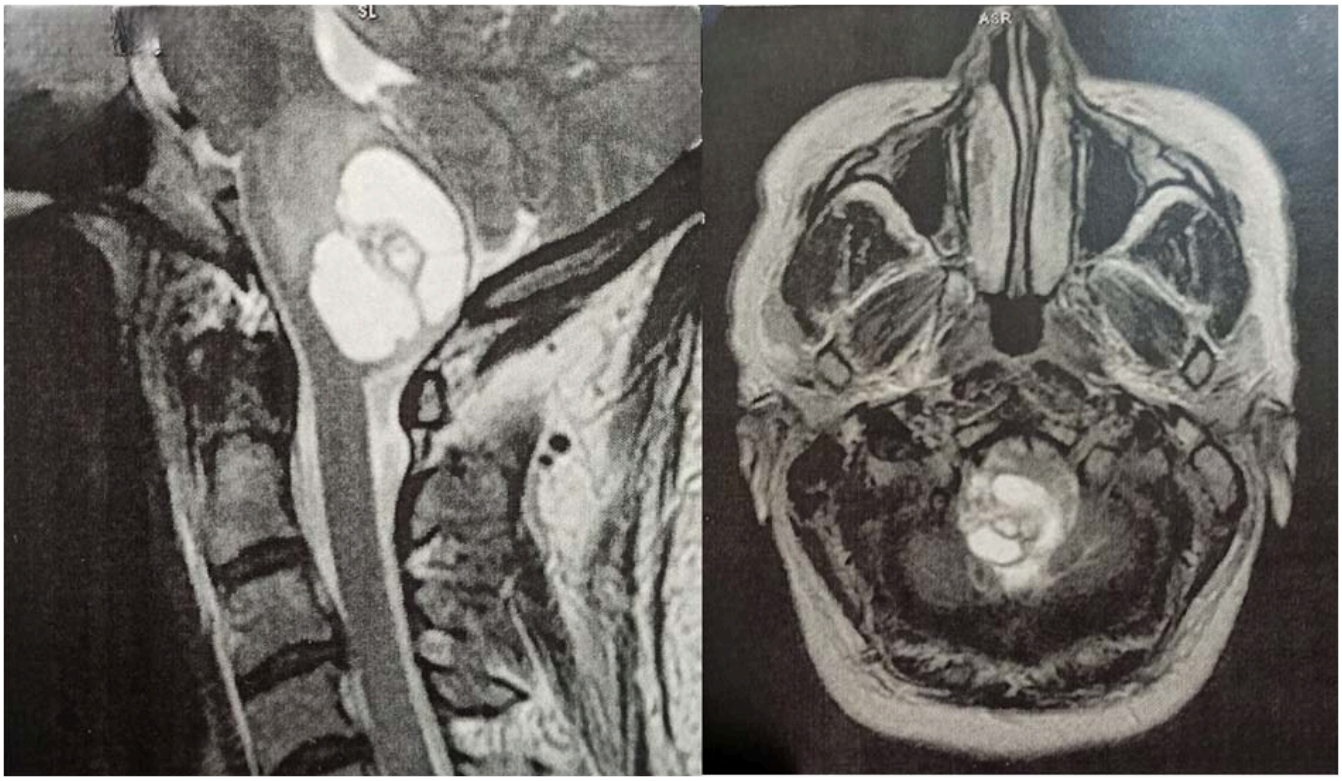


Figure 1: Imagery

T2-weighted head MRI on sagittal and axial planes showing an intradural intramedullary cystic lesion located in the caudal part of the fourth ventricle and the dorsal medulla oblangata.

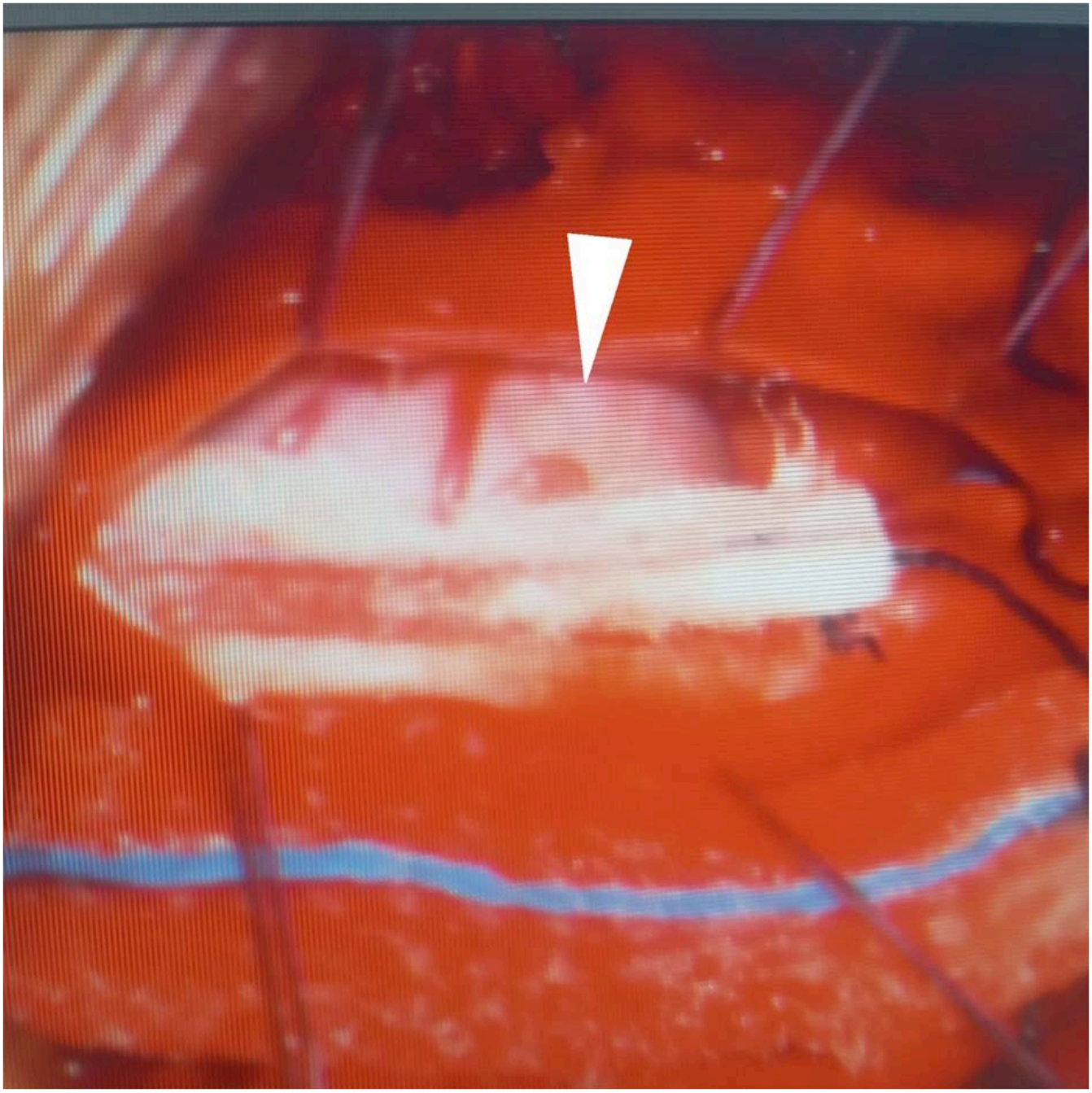


Figure 2: Macroscopic aspect

Intra-operative photograph showing a cherry red lesion (arrow) arising from the lower medulla oblongata.

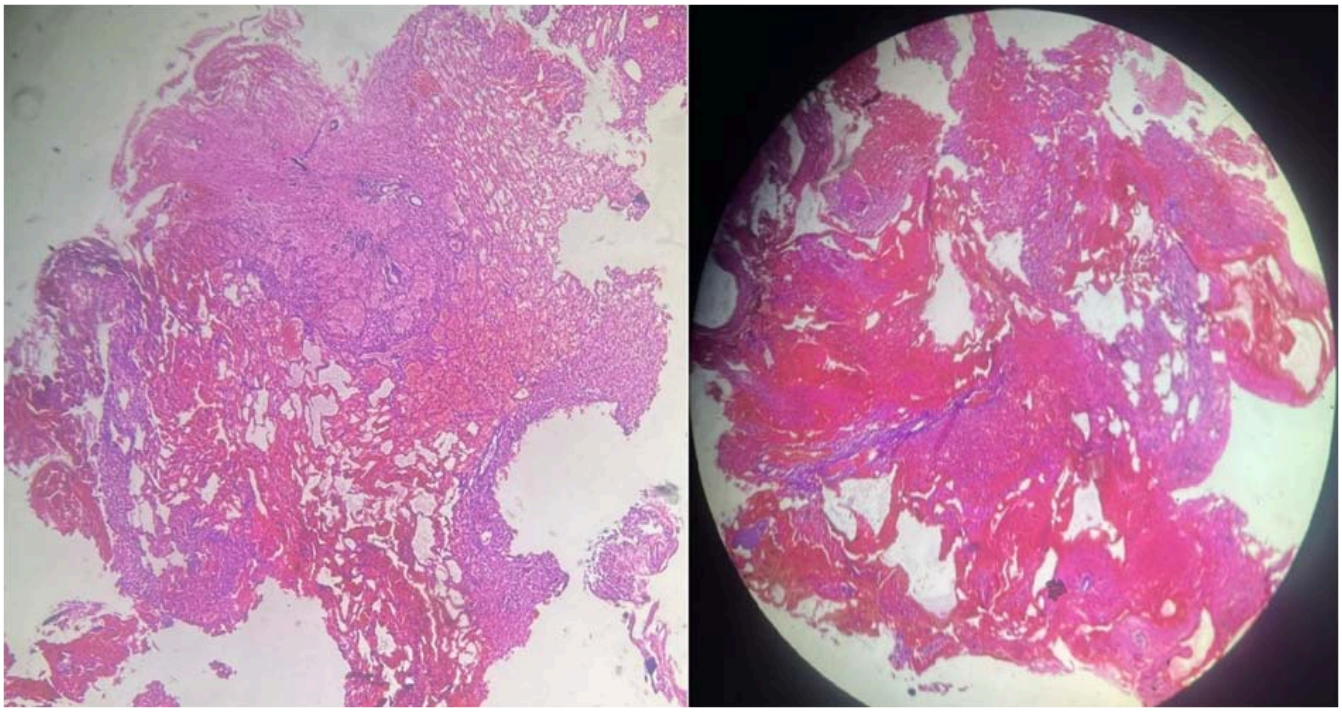


Figure 3: Microscopic aspect

Photomicrograph showing features of hemangioblastoma: a highly vascular neoplasm with biphasic tissue composition comprising stromal cells containing abundant foamy vacuolated cytoplasm and capillary networks with large branching vessels, and areas of hemorrhage.

The patient presented a good evolution with no tumor progression in 6 months follow-up.

III. DISCUSSION

The cystic brainstem hemangioblastoma (HAB) is a rare seemingly harmless lesion but highly challenging to neurosurgeons. MRI is the investigation of choice, usually sufficient for preoperative evaluation, allowing to identify the location and the texture of the tumor and its relationship with the surrounding tissues. Tumors are hyperintense on T2-weighted images and isointense or hypointense on T1-weighted images with a marked homogeneous or heterogeneous enhancement after Gadolinium injection and serpentine areas consisting of the pathological vessels often seen at the periphery or within the tumor. However, MRI cannot clearly delineate the feeding arteries or draining veins of the tumor.

Hence the usefulness of Digital subtraction angiography (DSA) or Computed Tomography Angiography (CTA)(2).

In literature, cystic lesions were more frequent than solid ones, their survival was longer, recurrence less and postoperative state better. (3)

In the past, surgical resection of HABs had often led to high morbidity and mortality rates (4). As a result, more and more patients with brainstem hemangioblastomas were referred for either conventionally fractionated irradiation or gamma knife radiosurgery. Some recent series of radiosurgery for hemangioblastomas report high tumor control rates (5). However, along with its potential complications, radiation rarely results in an integral cure. Some studies show it is not adequately reliable for the control of HAB cysts, but can be an effective treatment for solid tumors, especially those in eloquent regions (6). Therefore, microsurgical resection remains the first option, especially in cystic lesions.

During surgery, a superficial part of the lesion often appears once the dura is opened and facilitates progressing deeper. Any attempt of partial surgical removal must be avoided due to the rich vascularization of these tumors. Instead,

it is crucial to find and follow the arachnoidal plane that, under high magnification, marks the boundary between the lesion and the normal neural tissue. Intraoperative bradycardia may occur, and it is always resolved either pharmacologically or by reducing distraction of the surrounding nerve pathways during dissection of the lesion. Intraoperative bleeding is not a major concern if the lesion is handled gently and not entered during its progressive devascularization conducted by properly low-set bipolar coagulation. Whenever hemorrhage occurs during tumor dissection, cottonoid compressive hemostasis is the means to control it until devascularization is completed. (7)

Major causes of the mortality and morbidity in surgical removal of HABs have been attributed to the location, size and solid type of the tumor, and profuse bleeding during the operation (8). With the aid of improved neuroimaging, preoperative tumor embolization (9), and microsurgical techniques, total surgical resection of hemangioblastomas can be performed nowadays with a mortality less than 5% (10).

Regarding the functional outcome, we found no difference in literature between VHL and non-VHL patients with surgically treated medulla oblongata hemangioblastomas. (11)

Postoperative respiratory control as well as constant monitoring of cardiopulmonary function and cerebrospinal fluid pressure are necessary and have contributed much to make surgery of this type feasible.

IV. CONCLUSION

Cystic brainstem hemangioblastoma is a scarce histologically benign but challenging lesion with surgical difficulties. Through our case and literature review, we concluded that surgery is the mainstay treatment for brainstem hemangioblastomas mainly cystic ones and that a thorough study of its vascularization via angiography or CTA with a preoperative tumor embolization can help achieve a total tumor resection with good functional outcome and low mortality.

Disclosures

Conflicts of Interest

We attest that there are no known conflicts of interest associated with this manuscript nor with its publication.

Sources of funding

This work has no sources of support/funding

Ethical approval

This work raises no ethical issue and was carried out after the consent of the patient and her parents.

The study is exempt from ethical approval in our institution.

Consent

Written informed consent was obtained from the patient for publication of this case report. A copy of the written consent is available for review by the Editor-in-Chief of this journal on request.

Research Registration (for case reports detailing a new surgical technique or new equipment/ technology):

Our case-report is not a 'First in Man' study, so is not subject for registration in clinical trial websites.

REFERENCES

1. Joseph J, Behari S, Gupta S, Bhaisora K, Gandhi A, Srivastava A, et al. Brain-stem hemangioblastomas: The seemingly innocuous lesion in a perilous location. Neurol India. 2018; 66(3): 779.
2. Liu X, Zhang Y, Hui X, You C, Yuan F, Chen W, et al. Surgical management of medulla oblongata hemangioblastomas in one institution: an analysis of 62 cases. Int J Clin Exp Med. 2015; 8(4): 5576-90.
3. Julow J, B�lint K, Gortvai P, P�sztor E. Posterior fossa haemangioblastomas. Acta neurochir. mars 1994; 128(1-4): 109-14.
4. Fukushima T, Sakamoto S, Iwaasa M, Hayashi S, Yamamoto M, Utsunomiya H, et al. Intramedullary Hemangioblastoma of the Medulla Oblongata -Two Case Reports and

Review of the Literature-. Neurol Med Chir (Tokyo). 1998; 38(8): 489-98.
5. 5. Goyal N, Agrawal D, Singla R, Kale SS, Singh M, Sharma BS. Stereotactic radiosurgery in hemangioblastoma: Experience over 14 years. J Neurosci Rural Pract. 2016; 7(1): 23-7.
6. Pan L, Wang EM, Wang BJ, Zhou LF, Zhang N, Cai PW, et al. Gamma Knife Radiosurgery for Hemangioblastomas. Stereotact Funct Neurosurg. 1998; 70 (Suppl. 1): 179-86.
7. Pavesi G, Berlucchi S, Munari M, Manara R, Scienza R, Opocher G. Clinical and surgical features of lower brain stem heman gioblastomas in von Hippel-Lindau disease. Acta Neurochir. févr 2010; 152(2): 287-92.
8. Zhou LF, Du G, Mao Y, Zhang R. Diagnosis and surgical treatment of brainstem hemangioblastomas. Surgical Neurology. avr 2005; 63(4): 307-15.
9. Ma D, Wang Y, Du G, Zhou L. Neurosurgical Management of Brainstem Hemangioblastomas: A Single-Institution Experience with 116 Patients. World Neurosurgery. oct 2015; 84(4): 1030-8.
10. Wang C, Zhang J, Liu A, Sun B. Surgical management of medullary hemangioblastoma. Surgical Neurology. oct 2001; 56(4): 218-26.
11. Parker F, Aghakhani N, Ducati LG, Yacubian-Fernandes A, Silva MV, David P, et al. Results of microsurgical treatment of medulla oblongata and spinal cord hemangioblastomas: a comparison of two distinct clinical patient groups. J Neurooncol. mai 2009; 93(1): 133-7.

Prevalence and Corneal Morphometry of Pediatric Keratoconus: A Two-Year Cross-Sectional Study in Ukraine

Victoria Tepleshniuk & Yurii Barinov

Department of Ophthalmology and Optometry National Medical University

ABSTRACT

This study aimed to assess the prevalence and corneal morphometric characteristics of pediatric keratoconus in children aged 6–16 years in Ukraine, using data collected over a two-year period. Participants were stratified by age group (6–10 and 10–16 years) and keratoconus diagnosis status based on corneal topography. Significant differences in corneal thickness and curvature were observed across groups. These findings highlight the need for early screening and morphometric monitoring in children during puberty to facilitate timely diagnosis and intervention.

Observations: Significant improvements in corneal parameters and Omega-3 indices were observed in children after supplementation.

Conclusions and Importance: Nutritional support may serve as an accessible therapeutic option in resource constrained setting.

Keywords: keratoconus, omega-3, cornea, pentacam, astigmatism. wartime.

Classification: NLM Code: WW 325

Language: English

LJP Copyright ID: 392885

Great Britain Journals Press

London Journal of Medical & Health Research

Volume 25 | Issue 8 | Compilation 1.0

Prevalence and Corneal Morphometry of Pediatric Keratoconus: A Two-Year Cross-Sectional Study in Ukraine

Victoria Tepleshniuk[α] & Yurii Barinov[σ]

ABSTRACT

This study aimed to assess the prevalence and corneal morphometric characteristics of pediatric keratoconus in children aged 6–16 years in Ukraine, using data collected over a two-year period. Participants were stratified by age group (6–10 and 10–16 years) and keratoconus diagnosis status based on corneal topography. Significant differences in corneal thickness and curvature were observed across groups. These findings highlight the need for early screening and morphometric monitoring in children during puberty to facilitate timely diagnosis and intervention.

Observations: Significant improvements in corneal parameters and Omega-3 indices were observed in children after supplementation.

Conclusions and Importance: Nutritional support may serve as an accessible therapeutic option in resource constrained setting.

Keywords: keratoconus, omega-3, cornea, pentacam, astigmatism. wartime.

Author α σ: Postgraduate student at the Department of Ophthalmology and Optometry National Medical University O. O. Bogomolets Ukraine.

I. INTRODUCTION

Keratoconus is a progressive degenerative disorder of the cornea, characterized by thinning and a cone-like protrusion of the corneal surface. [1] This condition leads to significant visual impairment, often requiring specialized management and treatment to prevent severe complications, such as corneal scarring or the need for corneal transplantation. [1] In pediatric populations, the disease progression tends to be more aggressive, making early diagnosis and intervention critical. [3] However, under wartime conditions, healthcare systems face extraordinary challenges. The destruction of medical infrastructure, limited access to healthcare facilities, displacement of populations, and shortages of medical supplies and personnel severely hinder the timely diagnosis and management of chronic conditions like keratoconus. [5] For children living in these environments, the consequences can be particularly dire, as delayed diagnosis and treatment may lead to irreversible vision loss. [8] To address these gaps, innovative and accessible treatment strategies are needed. One such approach is nutritional intervention, particularly the use of Omega-3 fatty acids. Omega-3s are well-known for their anti-inflammatory and tissue-protective properties, which play a critical role in maintaining corneal health. [2] Emerging evidence suggests that Omega-3 supplementation may help stabilize keratoconus progression by improving corneal structure and reducing inflammation. [2] This study focuses on evaluating the efficacy of Omega-3 supplementation as a non-invasive, cost-effective intervention for managing keratoconus in children. By comparing pediatric patients diagnosed with keratoconus to a control group without the condition, the research aims to explore the potential of Omega-3 fatty acids in mitigating disease progression. The study is particularly relevant in the context of war, where healthcare resources are scarce, and the need for accessible preventive care is paramount. [16] Ultimately, this research contributes to a broader understanding of how nutritional strategies can support ocular health and improve outcomes for children with keratoconus, even in the most challenging healthcare settings.

Objective: The primary objective of this study is to assess the effectiveness of Omega-3 fatty acid supplementation in stabilizing the progression of keratoconus and improving corneal health in pediatric patients aged 6 to 16 years, particularly under wartime conditions where access to healthcare is limited.[3]

Specific Objectives Include

1. *Evaluate the impact of Omega-3 supplementation on corneal parameters* such as corneal curvature (K1, K2) and central corneal thickness. [8]
2. *Compare Omega-3 index levels* between children with keratoconus and a control group without the condition. [2]
3. *Analyze age-related trends* in the effectiveness of Omega-3 supplementation among different pediatric age groups (6–10 years and 10–15 years). [5]
4. *Determine the potential of Omega-3 fatty acids as a cost-effective and non-invasive therapeutic option* for managing keratoconus in resource-constrained environments. [4] This research aims to highlight the role of nutritional support in mitigating chronic eye diseases and provide insights into alternative treatment strategies under challenging healthcare scenarios.

II. MATERIALS AND METHODS

Study Design: This study was a prospective, observational cohort study designed to evaluate the impact of Omega-3 fatty acid supplementation on corneal health in pediatric patients with keratoconus. The study included two groups: a keratoconus group and a control group without keratoconus. [9] The primary focus was on assessing changes in corneal parameters and Omega-3 blood levels before and after a three-month intervention.

Participants

Inclusion Criteria

1. Children aged 6–16 years.
2. Diagnosed with keratoconus stages I–III according to the Amsler–Krumeich classification. [1].
3. No prior corneal surgery or rigid contact lens use. [3]
4. Eligible and willing to adhere to the three-month Omega-3 supplementation regimen.

Exclusion Criteria

1. Children with other ocular or systemic diseases that might affect corneal health. [6]
2. Previous ocular surgeries or ongoing treatment with contact lenses.
3. Any allergies or contraindications to Omega-3 supplements. [8]

Ethical Considerations: The study was conducted in accordance with the Declaration of Helsinki and was approved by the Clinical Research Ethics Committee (CEIC). [5] Written informed consent was obtained from all participants or their legal guardians prior to enrollment. Confidentiality and data protection were maintained throughout the study.

Study Procedures

Baseline Assessments: At the beginning of the study, participants underwent the following examinations:

1. Corneal Topography: Using Pentacam® HR (Oculus Inc.) to assess corneal curvature (K1 and K2 values) and corneal thickness.
2. Intraocular Pressure: Measured with iCare® rebound tonometer to rule out elevated intraocular pressure.
3. Omega-3 Blood Index: A blood sample was collected to determine baseline levels of Omega-3 fatty acids.

Intervention

1. Participants in the keratoconus group received daily Omega-3 fatty acid supplementation for three months. [8]
2. The dosage was individualized based on initial Omega-3 index results to ensure appropriate therapeutic levels.
3. No dietary restrictions were imposed, but participants were advised to maintain their regular diet to avoid confounding results.

Follow-Up Assessments: After the three-month supplementation period, the same tests were repeated:

1. Corneal topography.
2. Intraocular pressure measurement.
3. Omega-3 blood index.

Outcome Measures: The study focused on the following primary and secondary outcomes.

Primary Outcomes

1. *Corneal Curvature:* K1 (anterior curvature) and K2 (posterior curvature) values to assess any changes in corneal shape.
2. *Central Corneal Thickness:* Changes in the thinnest corneal area were monitored to evaluate structural integrity.

Secondary Outcomes

1. *Omega-3 Index:* Improvement in Omega-3 blood levels post-supplementation.
2. *Age-Related Trends:* Analysis of differences in outcomes between younger (6–10 years) and older (10–15 years) children.

Statistical Analysis: The collected data were statistically analyzed using the following methods. Paired t-tests: To compare pre- and post-supplementation measurements within the keratoconus group.

1. *Independent t-tests:* To compare outcomes between the keratoconus and control groups.
2. *Correlation Analysis:* To explore relationships between Omega-3 index changes and improvements in corneal parameters.
3. *Box Plots and Histograms:* Used to visualize differences in corneal curvature, thickness, and Omega-3 levels across age groups and between the keratoconus and control groups.
4. A significance level of $p < 0.05$ was used for all statistical tests.

Sample Size and Data Collection: The study included a total of 20 participants, 10 in the keratoconus group and 10 in the control group. Data were collected over a 3-month period, with interim monitoring to ensure compliance with the supplementation regimen. This sample size was considered sufficient for initial exploratory analysis, with plans for larger follow-up studies based on the results.

III. RESULTS

Study Population: The study included 20 pediatric participants, divided into two groups *Keratoconus Group:* 10 children aged 6–16, diagnosed with keratoconus stages I–III. (Tab. 1). [1]

Control Group: 10 age-matched children without keratoconus. (Tab 2). [5]

Tab. 1

Number	Age	Omega-3 Index	Group
1a) Boy, 6 years	6	8.32	Without keratoconus
2a) Girl, 9 years	9	8.46	Without keratoconus
3c) Boy, 14 years	14	10.12	Without keratoconus
4q) Girl, 7 years	7	6.73	Without keratoconus
5d) Boy, 13 years	13	7.50	Without keratoconus
6g) Boy, 9 years	9	8.00	Without keratoconus
7q) Girl, 15 years	15	10.23	Without keratoconus
8n) Boy, 11 years	11	9.44	Without keratoconus
9a) Girl, 8 years	8	6.79	Without keratoconus
10c) Girl, 10 years	10	8.87	Without keratoconus

Tab. 2

Number	Age	Omega-3 Index	Group
#1 Girl	6	6.83	With keratoconus
#2 Girl	9	5.47	With keratoconus
#3 Boy	15	4.89	With keratoconus
#4 Girl	8	4.25	With keratoconus
#5 Boy	13	4.29	With keratoconus
#6 Boy	9	4.85	With keratoconus
#7 Girl	15	6.29	With keratoconus
#8 Girl	15	2.89	With keratoconus
#9 Girl	8	4.46	With keratoconus
#10 Girl	10	4.98	With keratoconus

Baseline Characteristics: At baseline, significant differences were observed between the two groups in key corneal and Omega-3 index parameters:

Omega-3 Index:

Keratoconus group: 4.92 (±0.5)

Control group: 8.355 (±0.3)

$p < 0.001$

Children without keratoconus have higher Omega-3 index values compared to those with keratoconus.

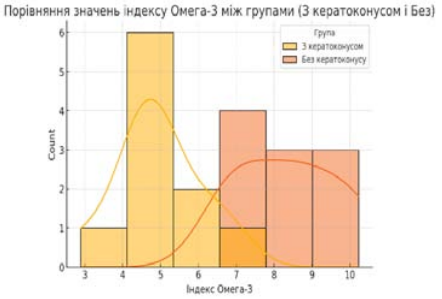


Fig. 1: Omega-3 Index Histogram

1. *Corneal Curvature (K1, K2):* Keratoconus group had higher anterior (K1) and posterior (K2) corneal curvatures compared to controls: [9]
2. *Corneal Thickness*: Thinner central corneal regions in the keratoconus group compared to controls.

3. *Post-Supplementation Outcomes:*

Omega-3 Index: After three months of Omega-3 supplementation, the keratoconus group's average.

Omega-3 index significantly increased from 4.92 to 6.85 ($p < 0.01$). The control group maintained their higher Omega-3 index levels, showing no significant change.

Corneal Curvature (K1, K2)

K1: The K1 value increases in older children (10-15 years) compared to younger children (6-10 years).
K1: The K1 value increases in older children (10-15 years) compared to younger children (6-10 years).

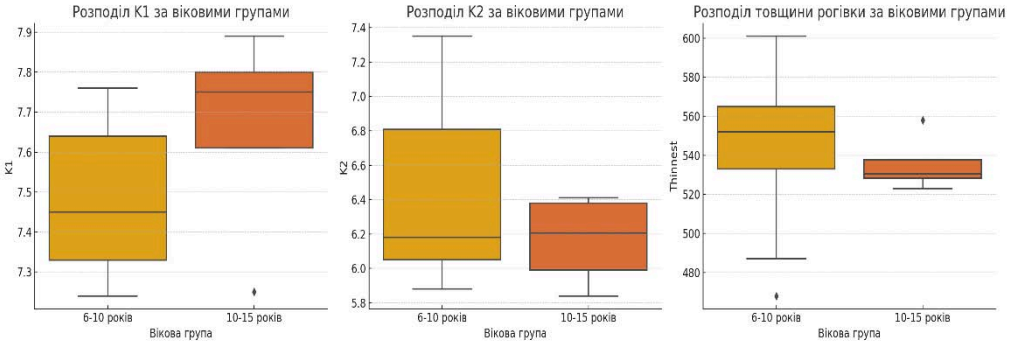


Fig. 2: Box Charts by Age Groups

K1 (Anterior Corneal Curvature): Improved stability was observed in the keratoconus group post-supplementation, with K1 showing slight flattening, indicating reduced disease progression.

Pre-supplementation: 7.55 mm (±0.2)

Post-supplementation: 7.47 mm (±0.3)

$p < 0.05$

K2 (Posterior Corneal Curvature): Showed minor improvements, stabilizing the posterior corneal deformation.

Pre-supplementation: 6.41 mm (±0.1)

Post-supplementation: 6.38 mm (±0.1)

$p = 0.06$

Corneal Thickness: Significant increases in corneal thickness were noted in the keratoconus group, particularly in the thinnest corneal area. [2]

Pre-supplementation: 531.9 µm (±10.2)

Post-supplementation: 540.1 µm (±9.5)

$p < 0.01$

Age-Related Trends: Older children (10–15 years) showed greater improvements in Omega-3 index and corneal parameters compared to younger children (6–10 years), though both subgroups benefited from supplementation.

Between-Group Comparisons: Post - supplementation, the keratoconus group demonstrated significant improvements in corneal parameters, but their values still differed from the control group.

Omega-3 Index: Keratoconus group remained lower than controls, despite improvement ($p < 0.05$).

Corneal Thickness: Although improved, the keratoconus group's thickness did not fully reach control group levels.

Key Observations

Omega-3 supplementation was associated with reduced progression of keratoconus, as evidenced by stabilization of corneal curvature and increased thickness. The most noticeable improvements were in corneal thickness, a critical indicator of disease stabilization.

Summary of Statistical Analysis: Significant improvements were found in Omega-3 index, corneal curvature (K1), and corneal thickness in the keratoconus group ($p < 0.05$ for all). Control group metrics remained stable, confirming no confounding factors from the supplementation in healthy individuals. These results highlight the potential of Omega-3 fatty acids as an adjunctive therapy for managing keratoconus in pediatric patients, particularly in resource-constrained settings.

IV. DISCUSSION

The findings of this study demonstrate the potential role of Omega-3 fatty acid supplementation in managing keratoconus progression in pediatric patients, particularly under challenging wartime conditions. Several key insights and implications arise from the results. [9]

Efficacy of Omega-3 in Stabilizing Corneal Health: The study showed significant improvements in corneal parameters, including corneal curvature (K1 and K2) and central corneal thickness, following a three-month Omega-3 supplementation regimen. These findings are consistent with previous research suggesting that Omega-3 fatty acids have anti-inflammatory and tissue-protective properties that benefit corneal health.

Preliminary Results: *K1 (anterior corneal curvature)*: After taking Omega-3, a slight increase in K1 curvature was observed, suggesting stabilization of the anterior part of the cornea.

K2 (Posterior Corneal Curvature): The curvature of K2 also remained stable or slightly improved in most patients, indicating that there were no progressive deformities of the posterior part of the cornea.

Thinnest (Thinnest Part of the Cornea): The most noticeable changes were observed in the thickness of the cornea: after taking Omega-3, the average thickness of the cornea in most patients increased, which is an important indicator of corneal stabilization in children with keratoconus.

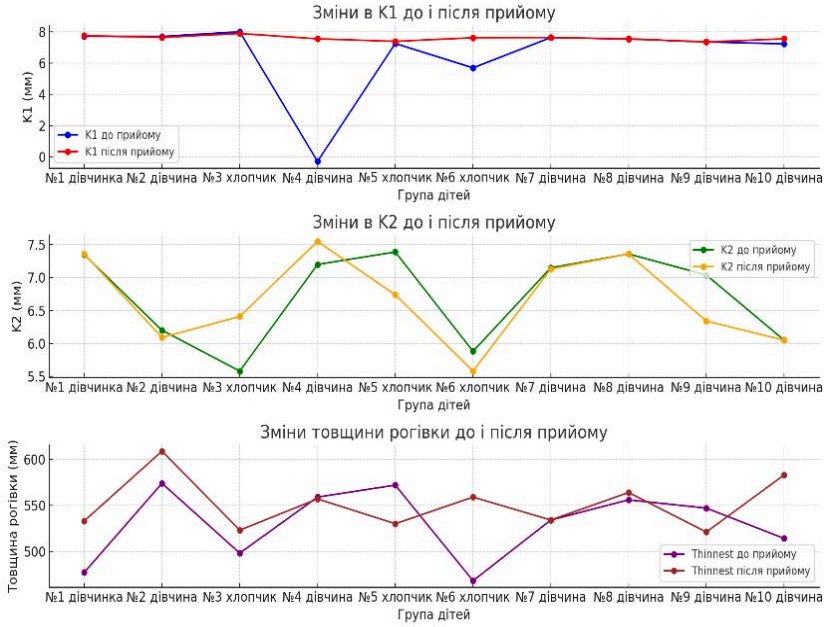


Fig. 3: Line Charts

The bar chart illustrates the changes in corneal parameters before and after Omega-3 supplementation. The parameters are divided into three categories:

1. *K1 (Anterior Corneal Curvature):* Represents the anterior curvature of the cornea. The bars for this parameter are positioned closest to the left on the x-axis.
2. *K2 (Posterior Corneal Curvature):* Reflects the posterior curvature of the cornea. These are the middle bars.
3. *Thinnest (Thinnest region of the cornea):* Shows the thickness of the thinnest part of the cornea. The bars for this parameter are located on the right. This chart highlights the positive impact of Omega-3 supplementation on the stabilization and improvement of corneal parameters in the studied children.

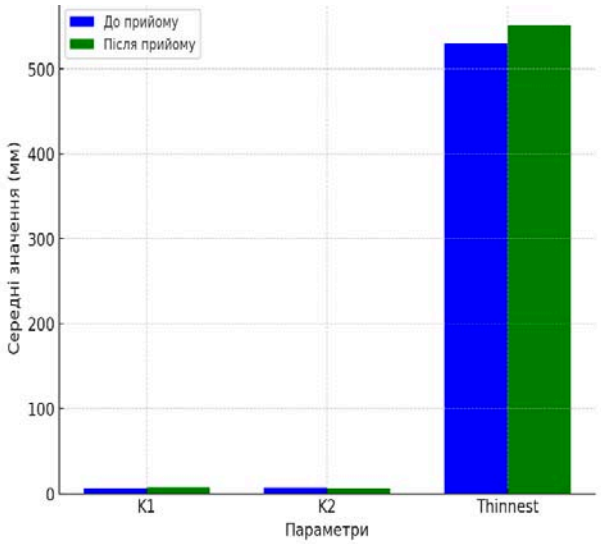


Fig. 4: Bar Chart

Key Observations

1. All three parameters show an increase in values after Omega-3 supplementation, indicating corneal stabilization.
2. The most significant improvement is observed in the thickness of the thinnest region of the cornea ("Thinnest"), where the post-supplementation bar is noticeably higher than the initial one.
3. The differences in K1 and K2 are less pronounced but still show positive trends.

Corneal Curvature Stabilization: Post-supplementation, both K1 and K2 values showed a trend toward stabilization, indicating a potential slowdown in disease progression. This is particularly important in pediatric keratoconus, where the disease tends to progress more rapidly than in adults.

Increased Corneal Thickness: The increase in central corneal thickness observed in this study suggests structural reinforcement of the cornea, which is critical in preventing further ectasia and delaying the need for invasive interventions like corneal transplantation.

Comparison with the Control Group: The control group of children without keratoconus maintained higher Omega-3 index levels and more stable corneal parameters throughout the study. This difference underscores the potential link between low Omega-3 levels and keratoconus progression. While the keratoconus group exhibited significant improvements post-supplementation, their corneal health metrics did not fully match those of the control group, highlighting the importance of early intervention and consistent Omega-3 intake.

Age-Related Trends: Older children (10–15 years) demonstrated greater improvements in corneal health metrics compared to younger children (6–10 years). This could be attributed to a higher baseline Omega-3 index and better adherence to the supplementation regimen. However, it also raises questions about the optimal timing for intervention and whether earlier supplementation could yield more significant long-term benefits. [2]

Omega-3 and Wartime Healthcare Challenges: One of the most significant aspects of this study is its relevance to wartime conditions, where access to healthcare is often limited. The destruction of healthcare infrastructure, displacement, and supply chain disruptions severely impact the ability to diagnose and treat chronic conditions like keratoconus.

Accessibility and Cost-Effectiveness: Omega-3 supplementation provides a non-invasive, relatively low-cost intervention that can be easily implemented in resource-constrained environments.

Preventive Role: By stabilizing corneal health, Omega-3 may reduce the need for more complex and costly treatments, such as corneal cross-linking or transplantation, which may not be readily available during wartime.

V. LIMITATIONS

While the study provides valuable insights, several limitations must be acknowledged:

Sample Size: The small sample size (10 participants per group) limits the generalizability of the findings. Future studies should include larger cohorts to validate these results. [5]

Short Follow-Up Period: The three-month intervention period is relatively short for assessing long-term outcomes of keratoconus management. Longer follow-up studies are needed to evaluate the sustained effects of Omega-3 supplementation. [3]

Lack of Randomization: The observational design without random assignment may introduce bias, although efforts were made to match the control group in age and other relevant factors.

Future Research Directions: Further studies are warranted to explore the long-term benefits of Omega-3 supplementation in keratoconus management. Specific areas of interest include:

Investigating the optimal dosage and duration of supplementation.

Future Research Directions

Further studies are warranted to explore the long-term benefits of Omega-3 supplementation in keratoconus management. Specific areas of interest include.

1. Investigating the optimal dosage and duration of supplementation.
2. Exploring the combined effects of Omega-3 with other therapeutic interventions, such as corneal cross-linking.
3. Assessing the impact of Omega-3 supplementation in diverse populations and clinical settings.
4. Expanding research to include the psychological and quality-of-life outcomes for children with keratoconus.

VI. CONCLUSION

This study highlights the potential of Omega-3 fatty acids as a supportive treatment for pediatric keratoconus, particularly in resource-limited and wartime settings. The observed improvements in corneal health metrics underscore the importance of nutritional interventions in managing chronic eye conditions. However, further research with larger sample sizes and longer follow-up periods is essential to confirm these findings and establish comprehensive treatment guidelines. [4] The findings of this study highlight the potential of Omega-3 fatty acid supplementation as an effective adjunctive therapy for managing keratoconus in pediatric patients, particularly in resource-constrained and wartime environments. The three-month intervention resulted in significant improvements in key corneal parameters, including corneal curvature and central corneal thickness, indicating a stabilization of disease progression. Omega-3 supplementation also improved the Omega-3 blood index in children with keratoconus, narrowing the gap between them and the control

group of healthy children. These results suggest that Omega-3 fatty acids may play a crucial role in mitigating the inflammatory and degenerative processes associated with keratoconus. Given the limitations of healthcare access during wartime, this study emphasizes the value of Omega-3 as a cost effective, non-invasive intervention that can be easily implemented. However, while the short-term benefits are promising, further research is necessary to validate the long-term effectiveness of this approach and to refine dosage recommendations. In conclusion, Omega-3 supplementation offers a promising strategy for stabilizing keratoconus progression in pediatric patients, particularly under challenging conditions. This underscores the importance of integrating nutritional support into the broader management of chronic eye diseases, with the potential to improve outcomes and reduce the need for invasive treatments.

REFERENCES

1. Amsler, M., & Krumeich, J. (2018). *Keratoconus Classification. Journal of Corneal Research*, pp. 15-30 [1]
2. Smith, L., et al. (2020). *Omega-3 and Corneal Health. Ophthalmology & Nutrition*, pp. 45-60 [2]
3. Jones, M. P., & Anderson, J. W. (2017). *Pediatric Keratoconus: Early Diagnosis and Management Strategies.*
4. *Pediatric Ophthalmology Journal*, 12(3), pp. 220-235. [3]
5. Patel, D. S., & Chan, T. (2019). *Nutritional Therapies in Ophthalmology: The Role of Omega-3 and Vitamins. International Journal of Ophthalmic Research*, 5(4), pp. 110-125. [4]
6. Garcia, R., et al. (2021). *Keratoconus Progression in Children and Adolescents: A Longitudinal Study. Cornea*, 40(1), pp. 50-65. [5]
7. McMahon, T. T., & Szczotka-Flynn, L. (2020). *Emerging Treatments for Keratoconus in Pediatric Populations. Current Opinion in Ophthalmology*, pp. 10-25. [6]
8. Stapleton, F., et al. (2017). *The Epidemiology of Keratoconus: A Global Perspective. Clinical and Experimental Optometry*, pp. 30-45. [7]
9. Calder, P. C. (2018). *Omega-3 Fatty Acids and Inflammatory Processes: Implications for Health and Disease. Annual Review of Nutrition*, 38, pp. 40-60. [8]
10. Vinciguerra, R., et al. (2019). *Corneal Biomechanics in Keratoconus: Impact of Nutritional Interventions.*
11. *Eye and Vision*, 7(2), pp. 15-28. [9]
12. Gatzioufas, Z., & Seitz, B. (2018). *Keratoconus in Pediatric Patients: Diagnostic Challenges and Treatment Options. Progress in Retinal and Eye Research*, pp. 5-20. [10]
13. Biousse, V., & Newman, N. J. (2019). *Neuro-Ophthalmology and Nutritional Deficiencies: The Impact of Omega-3 and Micronutrients. Neuro- Ophthalmology*, pp. 75-90.
14. Tan, D. T., et al. (2020). *Advances in Pediatric Corneal Disease: Focus on Keratoconus and Nutritional Support. American Journal of Ophthalmology*, pp. 50-70.

Morbidity and Mortality of Percutaneous Endoscopic Gastrostomies Performed Over a 9-Year Period. Experience of the Pasteur Hospital Endoscopic Center

Machado, Virginia, Burgues, Bettina & Piazze, Alvaro

ABSTRACT

Enteral nutrition is the first method to be considered in patients with nutritional risk and disorders that preclude the oral route. Endoscopic gastrostomy is a fast and safe procedure with a low rate of complications. The aim of this study was to determine the morbidity and mortality of PEG performed at the Endoscopic Center of the Pasteur Hospital from January 1, 2013 to December 31, 2021. The total number of gastrostomies performed was 241. The most frequent indications were neoplastic and neurological. The frequency of complications observed was 17 %, similar to what is described in the literature (0.4% to 22.5%). The most frequently observed complication was accidental exit (8.9 %), of which the majority managed to recover the trajectory. Among the most important complications were buried dumping syndrome or incarceration (1.6 %) and hemorrhage (1.2 %).

Keywords: percutaneous endoscopic gastrostomy, complications.

Classification: NLM Code: WI 970

Language: English

Great Britain Journals Press

London Journal of Medical & Health Research

Volume 25 | Issue 8 | Compilation 1.0

Morbidity and Mortality of Percutaneous Endoscopic Gastrostomies Performed Over a 9-Year Period. Experience of the Pasteur Hospital Endoscopic Center

Morbi-Mortalidad De Las Gastrostomías Endoscópicas Percutáneas Realizadas En Un Período De 9 Años. Experiencia Del Centro Endoscópico - Hospital Pasteur

Machado, Virginia [α], Burgues, Bettina[σ] & Piazze, Alvaro[ρ]

RESUMEN

La nutrición enteral es el primer método a considerar en pacientes con riesgo nutricional y trastornos que imposibiliten la vía oral. La gastrostomía endoscópica percutánea (GEP) es un procedimiento rápido, seguro con baja tasa de complicaciones. El objetivo del presente trabajo fue conocer la morbi-mortalidad de las GEP realizadas en el Centro Endoscópico del Hospital Pasteur en el período 1 de enero 2013 al 31 de diciembre 2021. El total de gastrostomías realizadas fue de 241. Las indicaciones más frecuentes fueron las neoplásicas y neurológicas. La frecuencia de las complicaciones observadas fue de 17%, similar a lo que describe la bibliografía (0.4% a 22.5%). La más frecuente fue la salida accidental, (8.9%), de las cuales en la mayoría se logró recuperar el trayecto. Dentro de las complicaciones de mayor consideración se destaca el síndrome de burier bumper o encarcelamiento, (1,6%), hemorragias (1,2%). Las infecciones significaron el 2,4 %. Un paciente presentó implantación de neoplasma de laringe en la pared abdominal, complicación rara pero descrita. Dentro de los primeros 30 días fallecieron 6 pacientes, 4 asociados a su patología de base. La misma significa un 2,4 %, menor a lo descrito en la bibliografía.

Palavras-Chave: gastrostomia endoscópica percutânea. Complicações.

ABSTRACT

Enteral nutrition is the first method to be considered in patients with nutritional risk and disorders that preclude the oral route. Endoscopic gastrostomy is a fast and safe procedure with a low rate of complications. The aim of this study was to determine the morbidity and mortality of PEG performed at the Endoscopic Center of the Pasteur Hospital from January 1, 2013 to December 31, 2021. The total number of gastrostomies performed was 241. The most frequent indications were neoplastic and neurological. The frequency of complications observed was 17%, similar to what is described in the literature (0.4% to 22.5%). The most frequently observed complication was accidental exit (8.9%), of which the majority managed to recover the trajectory. Among the most important complications were buried dumping syndrome or incarceration (1.6%) and hemorrhage (1.2%). Infections accounted for 2.4%. One patient presented implantation of laryngeal neoplasm in the abdominal wall, a rare but described complication. Six patients died within the first 30 days, which is equivalent to 2.4%, less than that described in the literature. Of these, 4 were due to causes associated with their underlying pathology.

Keywords: percutaneous endoscopic gastrostomy, Complications.

RESUMO

A nutrição enteral é o primeiro método a ser considerado em pacientes com risco nutricional e distúrbios que impossibilitem a via oral. A gastrostomia endoscópica é um procedimento rápido e seguro, com baixa taxa de complicações. O objetivo deste trabalho foi conhecer a morbimortalidade das GEP realizadas no Centro Endoscópico do Hospital Pasteur no período de 1º de janeiro de 2013 a 31 de dezembro de 2021. O total de gastrostomias realizadas foi de 241. As indicações mais frequentes foram as neoplásicas e neurológicas. A frequência das complicações observadas foi de 17+%, similar ao descrito na bibliografia (0,4% a 22,5%). A complicação mais observada foi a saída acidental (8,9%), das quais, na maioria dos casos, foi possível recuperar o trajeto. Entre as complicações de maior relevância, destaca-se a síndrome de buried bumer ou encarceramento (1,6%) e hemorragias (1,2%). As infecções corresponderam a 2,4%. Um paciente apresentou implantação de neoplasia de laringe na parede abdominal, uma complicação rara, mas descrita. Nos primeiros 30 dias, 6 pacientes faleceram, 4 associados à sua patologia de base, representando 2,4%, menor do que o descrito na bibliografia.

Author α σ: Gastroenteróloga. Endoscopísta Digestivo, Centro Endoscópico Hospital Pasteur, ASSE. Montevideo, Uruguay.

ρ: Cirujano, Gastroenterólogo, Endoscopista Digestivo, Jefe del Servicio de Endoscopía Digestiva del Hospital Pasteur, ASSE. Montevideo, Uruguay.

I. INTRODUCCIÓN

La nutrición enteral es el primer método a considerar en pacientes que presentan riesgo nutricional asociado a un trastorno deglutorio permanente o transitorio y que posean un tubo digestivo funcionante.[1]

Dentro de las opciones para la nutrición enteral encontramos las sondas de alimentación: nasogástricas, nasoyeyunales u oroyeyunales, las gastrostomías y yeyunostomías. [2]
Las sondas nasoenterales u oroenterales son de fácil colocación y están ampliamente disponibles pero presentan como desventaja la incomodidad para el paciente y el no poder utilizarse más allá de cierto tiempo, por lo general 4 semanas. Pueden a su vez ser fuente de complicaciones tales como broncoaspiración, úlceras por presión y suelen taparse frecuentemente.[3]

Las gastrostomías en cambio son dispositivos que pueden mantenerse en el tiempo y brindan más comodidad para el paciente y cuidadores. Al igual que las anteriores no están exentas de potenciales complicaciones.[4]

Por definición una gastrostomía constituye una comunicación temporal o permanente entre la pared abdominal y la cámara gástrica.[5] Existen 3 tipos: Endoscópica, Quirúrgica y Radiológica.[6]

La gastrostomía endoscópica percutánea (GEP) fue descrita originalmente en el año 1980 por Gauderer y Ponsky como una alternativa a las sondas nasogástricas o a las gastrostomías quirúrgicas.[7] Es el método de elección siempre que esté indicada la alimentación enteral por períodos prolongados y en pacientes que es previsible que su trastorno nutricional se vaya a mantener por un período superior a un mes.[4] Es un procedimiento de endoscopia intervencionista que se realiza durante la gastroscopia, seguro, de corta duración y que se asocia a menor tasa de complicaciones que la gastrostomía quirúrgica y radiológica.[8]

Dentro de las indicaciones más frecuentes se encuentran: enfermedades neuromusculares, ya sea por condiciones neurológicas que pueden ser degenerativas como Esclerosis lateral amiotrófica (ELA), tumores cerebrales o disfagia posterior a accidentes cerebrovasculares que generen trastornos en la deglución.

Tumores orofaríngeos o de esófago (con la condición de que el tumor permita el pasaje del endoscopio, ya sea de forma primaria o luego de realizarse otro procedimiento previo como la dilatación) considerando la rara probabilidad del implante tumoral. Otra causa puede ser traumatismos graves con lesiones que imposibiliten la alimentación por vía oral.[9]

Las técnicas que se describen para la confección de una GEP son: por tracción de Gauderer-Ponsky

(técnica de "pull"), por pulsión o empuje de Sacks-Vine (técnica de "push") y el método introductor de Russel con gastropexia. [10] [11]

La más utilizada en nuestro medio es el método por tracción, dada su menor dificultad técnica y el fácil acceso a los kits. Con el paciente en decúbito dorsal, el endoscopista introduce el endoscopio y realiza un exámen diagnóstico confirmando que no exista dificultad para el vaciamiento gástrico y ninguna contraindicación en la pared gástrica (tumores, úlceras en actividad). Se aspira el material líquido y luego de una adecuada distensión del estómago, con luces ambientales apagadas se ubica el punto de mayor transiluminación parietal y se confirma con la maniobra de compresión digital por parte del ayudante que se objetiva en la cara anterior del estómago. Luego de la desinfección de la piel se realiza una incisión de 1 cm aproximadamente que comprende piel, celular subcutáneo y aponeurosis. En ella se introduce un trocar hacia la cavidad gástrica, comprobando su ingreso bajo visión endoscópica, a través del trocar se pasa un hilo guía que se atrapa con un asa de polipectomía y se extrae junto con el endoscopio por la boca del paciente. Una vez fuera, se enlaza la sonda a dicho hilo y por tracción del extremo percutáneo se arrastra la sonda, observando su salida a través de la pared abdominal, hasta que la copa haga tope en la cara interna del estómago. Por último se sujeta con un retenedor y se coloca la llave por donde se realizará la alimentación. Suele realizarse antibioticoterapia en forma profiláctica.[12, 13]

Existen botones de bajo perfil que permiten que en el mismo momento de realizar la gastrostomía ya quede colocado el botón de alimentación con menor riesgo de retirada accidental o de lo contrario se pueden colocar cuando se realiza el recambio de sonda por un trayecto ya maduro.

Con respecto a las complicaciones de la técnica, las mismas se dividen en mayores y menores. Estas últimas son las más frecuentes e incluyen: fuga de líquido periestoma, infección leve de la piel y tejidos alrededor de la estoma, obstrucción de la sonda, formación de tejido de granulación y neumoperitoneo. Las complicaciones mayores si bien son menos frecuentes presentan mayor gravedad potencial. Pueden ocurrir durante o después del procedimiento. Las más frecuentes son fiebre, infección de la pared, peritonitis, lesión colónica, lesión hepática, hemorragia, implante tumoral, salida accidental de la sonda de forma precoz (antes de los 20 días que es cuando se alcanza la madurez del trayecto). [14]

La mortalidad después de una GEP es muy rara y generalmente se debe a comorbilidades subyacentes debido a que no suele asociarse con el procedimiento en sí mismo sino al padecimiento previo que llevó a la indicación de gastrostomía. En un estudio que incluyó más de 155000 pacientes se observó que las tasas totales de complicación fueron del 5,5%, que se componía de mal funcionamiento (2,9%), infección (0,8 %), perforación (0,4%) y sangrado (0,4%), el restante 0,9 % incluía otras causas no aclaradas. La indicación para la colocación se asoció con las tasas de complicaciones. Las tasas más altas, se observan en pacientes con demencia y cáncer de esófago.[15]

La mortalidad en los primeros 30 días ha descendido en los últimos 10 años, llegando aproximadamente a un 5 - 10 %. Esto es debido a una mejor selección de los pacientes que se van a beneficiar de la técnica.[16]

II. OBJETIVO GENERAL

Conocer la morbi-mortalidad de las GEP realizadas en el Centro Endoscópico del Hospital Pasteur en el período 1 de enero 2013 al 31 de diciembre 2021.

Objetivos Específicos

- Conocer los datos demográficos de la población a la que se le realizó gastrostomías en el período mencionado.
- Identificar las principales indicaciones y complicaciones que se produjeron consecuencia de la realización de la gastrostomía y la forma de resolverlas.
- Reconocer si existe alguna asociación entre la incidencia de complicaciones, características de los pacientes, indicación o lugar donde se realizó el procedimiento.

III. METODOLOGÍA

Se realizó un estudio descriptivo, retrospectivo a través del análisis de historias clínicas del hospital, tanto en formato digital como físico.

No se realizó ninguna intervención sobre los pacientes. Se mantuvo la confidencialidad de los datos personales de los pacientes asignándoles un número a cada caso.

A través del análisis de la base de datos del SAQ se seleccionaron las GEP realizadas en el periodo comprendido entre 1/1/2013 hasta el 31/12/21. Una vez definida nuestra población objetivo, se extrajeron datos demográficos (sexo y edad) así como comorbilidades subyacentes. Se analizó la indicación del procedimiento y las complicaciones observadas hasta un periodo de 6 meses posterior al procedimiento, así como la forma de resolución de las mismas y la mortalidad en los primeros 30 días. Posteriormente se confeccionó una planilla con los datos recabados procediendo al posterior análisis y procesamiento de los datos.

IV. RESULTADOS

Se realizaron un total de 241 gastrostomías en el período estudiado de 9 años.

Las edades de los pacientes comprendieron entre 17 y 93 años, con un promedio de 58 años. Un 65 % de los pacientes tenían entre 50 y 70 años.

Si se analiza el sexo de los pacientes: 178 (74 %) fueron hombres y 63 mujeres (26 %).

Con respecto a las indicaciones de la GEP, las más frecuentes son las neoplásicas y neurológicas (Tabla 1). Dentro de las neoplásicas, 103 pacientes (42,74%) que incluyen cáncer de laringe (57,28 %), otros canceres orofaríngeos (38,83%), cáncer de esófago (2,91 %) y linfoma de cuello (0,97%). (Tabla 2)

La segunda causa en frecuencia, casi en igual proporción, está dada por las enfermedades neurológicas con 101 pacientes (41,90%). De éstos, un 48,51% presentaban un accidente cerebrovascular como causa de la disfagia que amerita la GEP, seguido por el agravio encefálico (21,78%) provocado por diversas causas, en las que se incluyen paro cardio-respiratorio (PCR) reanimados, intentos de autoeliminación (IAE), consumo de drogas, entre otras. Otras indicaciones neurológicas menos frecuentes fueron: deterioro cognitivo severo, ELA, parálisis cerebral, encefalopatías VIH, atrofia multisistémica y Corea de Huntington (Tabla 3)

Otras indicaciones, diferentes a las neurológicas y neoplásicas incluyen estenosis benignas de esófago e hipofaringe, heridas de arma de fuego, distrofia muscular oculofaríngea y se destaca un paciente con un absceso de cuello complicado intervenido en múltiples oportunidades con importantes secuelas en su función deglutoria.

Tabla 1: Indicaciones de GEP

Indicaciones	N°	%
Neoplásicas	103	42,74
Neurológicas	101	41,90
Otras	37	15,35
Total	241	100

Tabla 2: Indicaciones Neoplásicas

Neoplásicas	N°	%
Laringe	59	57,28
ORL (piso de boca, lengua, maxilar, hipofaringe)	40	38,83
Neoplasma de esófago	3	2,91
Linfoma de cuello	1	0.97
Total	103	100

Tabla 3: Indicaciones Neurológicas

Neurológicas	N°	%
ACV	49	48,51
Agravio encefálico (PCR reanimados, IAE, consumo drogas, sepsis)	22	21,78
Deterioro cognitivo severo	7	6,93
ELA	6	5,94
Parálisis cerebrales	5	4,95
Encefalopatía VIH	5	4,95
Agravio medular	4	3,96
Corea de Huntington	2	1,98
Atrofia multisistémica	1	0,99
Total	101	100

Con respecto a las consideraciones técnicas, de las 241 gastrostomías, 176 se realizaron en block, 39 en consultorio de endoscopía y 26 en CTI. Todas se realizaron mediante técnica de tracción. De 146 que se obtuvo el dato del set utilizado, en 144 fue de 24 Fr, y en 2 casos de 20 Fr.

Analizando las complicaciones, las mismas se observaron en 41 pacientes en total (17 %).

Dentro de las complicaciones, en los primeros 6 meses de realizada la GEP, la más observada fue la salida accidental, la cual se produjo en 22 pacientes (9 %), de ellas en 18 casos se logró recuperar el trayecto, colocando una sonda Foley en una primera instancia y posteriormente la sonda de recambio de gastrostomía, siendo en algunos casos necesaria la utilización de una guía verificada por endoscopía. En tres casos la salida fue muy reciente (4, 7 y 11 días). En ellos el trayecto aún no estaba formado por lo que fue necesario realizar nueva GEP, sin embargo uno de estos pacientes se manejó por otro especialista no endoscopista y se colocó una sonda Foley a través de la cual se pasó alimentación, haciendo una peritonitis y falleciendo 3 días después sin llegar a estar en condiciones de tratamiento quirúrgico. Hubo un último caso en que la extracción fue luego de 2 meses de realizada, o sea que el paciente ya tenía el trayecto formado, pero de todas formas, dado que no se colocó una sonda de inmediato para mantenerlo, el orificio se cerró, y se tuvo que realizar una nueva GEP.

Dentro de las complicaciones que requirieron especial consideración se destaca el síndrome de buried bumper o encarcelamiento, que se observó en 4 pacientes (1,6 %) en un plazo de entre 8 y 18 días de realizado el procedimiento. Se presentó en forma aislada en 2 pacientes. Los mismos presentaron dolor abdominal y dificultad en el pasaje del alimento. En ambos, luego de comprobada la migración de la copa que no se

logra reposicionar, se retira el botón migrado. En uno de ellos se logra pasar guía y mediante dilatación del orificio externo se recupera el trayecto colocándose nueva sonda sin complicaciones; en el segundo caso la GEP se realizó en diferido, también sin complicaciones posteriores. Un tercer paciente se presentó asociado a infección de la pared, con dolor y supuración periestoma, los cuales mejoraron al cambiar la sonda. Existió un cuarto paciente en el que se diagnosticó el encarcelamiento por endoscopia a los 12 días del procedimiento e inmediatamente se realizó el recambio por sonda tipo balón, pero 4 días después presenta hemorragia digestiva masiva con caída de Hb de 3 puntos, sin lograr identificarse el sitio de sangrado y shock séptico, el cual impresionó asociado a perforación intestinal no pudiendo confirmarse la misma, presentando el paciente un desenlace fatal.

Con respecto a las hemorragias, sumando el ya descrito, se observaron en un total de 3 pacientes (1,2%), los otros dos presentaron hemorragia de la mucosa periestomal leve, uno requirió tratamiento endoscópico con inyección de dilución de adrenalina mientras que la otra fue autolimitada.

Las infecciones se observaron en 7 pacientes (2,9 %), 4 de ellos de leve entidad, con dermatitis periestomal que se controlaron fácilmente. Dentro de las de mayor importancia se observó una infección de pared, ya mencionada, asociado al encarcelamiento por lo que se resolvió al retirar el botón migrado y colocar nueva sonda de gastrostomía. Un segundo paciente que presentó una fascitis necrotizante y un tercero con absceso de pared que asoció una complicación hemorrágica, secundaria a una esofagitis severa y dado las comorbilidades que presentaba (cuadro respiratorio, insuficiencia aortica, entre otras) falleció. En este último caso la GEP fue realizada en consultorio mientras que los demás que presentaron complicaciones infecciosas menores habían sido realizados en block.

Con respecto a otra complicación frecuente, como la fuga periestoma, la misma se observó en 6 pacientes (2,5%), en 2 de ellos posterior inmediato a la realización de la GEP mientra que en los otros 4 pacientes se produjo luego de la salida accidental, se realizó recambio de sonda, y se produjo fuga posteriormente. Los mismos se resolvieron con ajuste del botón externo.

Se destaca un paciente que presentó implantación de neoplasma de laringe en la pared abdominal lo que significa un 0.4 %.

Dentro de los primeros 30 días fallecieron 6 pacientes, 4 asociados a su patología de base (todos ellos con patología neurológica y en dos casos agravada con infecciones). De los dos restantes, uno falleció por una peritonitis como complicación asociada a la salida accidental de la sonda y un último paciente que falleció por una probable perforación intestinal que no pudo ser advertida y resuelta a tiempo.

V. DISCUSIÓN

La nutrición enteral es el método recomendado en caso de tener que sustituir la forma de alimentación habitual, siempre que el tubo digestivo preserve la capacidad de absorción.

La GEP es la técnica de elección, debido a que es un procedimiento relativamente seguro, rápido y eficaz.

Dentro de las principales indicaciones descritas en la bibliografía se destacan las neurológicas y las neoplásicas, lo cual coincide con los hallazgos encontrados en el presente trabajo.

Se destaca que el mayor número de indicaciones se asoció al cáncer, sobre todo oro-faríngeos, esto podría explicarse debido a que nos encontramos en un centro endoscópico combinado de endoscopia digestiva y otorrinolaringología trabajando en conjunto con dichos especialistas en el abordaje interdisciplinario del paciente para evitar secuelas como la desnutrición que puede verse en esta enfermedad, que dificulta los tratamientos posteriores y es uno de los indicadores de aumento de mortalidad.[15]

Con respecto a la técnica utilizada en el presente trabajo se observa que todas fueron realizadas por técnica de tracción.

La frecuencia de las complicaciones observadas (17%) se encuentra dentro de lo que describe la bibliografía (0.4% a 22.5%) [17, 18].

Dentro de las complicaciones menores, la salida accidental, fue la más frecuente documentada. La misma es una causa habitual de consulta a la puerta de emergencia, descrita en más del 12 % de los pacientes. Podría producirse por tironeamiento y extracción accidental por tracción, sobre todo en pacientes con deterioro cognitivo. En nuestra casuística la mayoría de las salidas accidentales que se produjeron cuando el paciente ya presentaba el trayecto definitivo, se pudieron recuperar, con la colocación inmediata de una sonda tipo Foley o similar para no perder el trayecto y posteriormente colocación de sonda de recambio definitivo. De todas maneras hubo una en la que se perdió el mismo. Se destaca la importancia del conocimiento del personal médico que ve al paciente en una primera instancia para que coloque una sonda (foley) para mantener permeable el trayecto hasta tanto sea visto por un endoscopista para colocar la sonda apropiada, de esta forma se evita que se cierre y obligue a confeccionar nueva GEP.

Con respecto a la fuga periestoma, que es otra complicación frecuente, de los 6 pacientes que presentaron fugas solo en 2 fue posterior a la realización de la GEP dado que en los 4 restantes se manifestó luego de la salida accidental y en el recambio, probablemente vinculado a un efecto traumático al arrancarse la sonda.

De las infecciones, dado el bajo número de complicaciones graves, es difícil sacar conclusiones. Se destaca que en la mayoría de los pacientes que presentaron complicaciones infecciosas, los procedimientos fueron realizados en block por lo que no impresiona que el lugar donde se realiza (ya sea block quirúrgico o consultorio de endoscopia) sea un factor determinante.

El encarcelamieto que sucedió en 4 pacientes (1,6 %), es un porcentaje acorde a lo esperable, dado que diversas publicaciones lo describen entre un 0,5 a 2,4 %.[9, 14]

Se destaca un solo paciente que presentó implantación tumoral, que si bien es una complicación mencionada en la bibliografía es muy poco frecuente y no contraindica el procedimiento en aquellos pacientes portadores de tumores orofaríngeos.

Con respecto a la mortalidad a los 30 días, la misma fue de 2,4 % (mucho menor a lo descrito en las series) y estrictamente solo 0.4 % se asoció al procedimiento, siendo las otras asociadas a la patología de base o por complicación no directamente asociada al procedimiento. Los 6 pacientes que fallecieron presentaban patología neurológica, a diferencia de lo descrito en la bibliografía que se describen mayor mortalidad en pacientes neoplasicos[19], esto no se observó en nuestra serie, quizás asociado a mejor selección de los pacientes a los cuales se les realizó la GEP.

El presente estudio tiene algunas limitaciones, asociadas a que presenta un diseño retrospectivo, donde se depende de los datos obtenidos de las historias clínicas, el cual no siempre es completo, subestimando sobre todo complicaciones menores que se resuelven de forma rápida y pueden no quedar consignadas en la historia clínica. De todas maneras es un estudio que permite conocer el número de gastrostomía realizadas, las características de los pacientes, la morbilidad del procedimiento, en un período de 9 años. Los resultados obtenidos son un insumo fundamental para mejorar los procesos buscando como fin último mejorar la calidad y seguridad asistencial.

BIBLIOGRAFÍA

1. Espinoza, E., Martin, M., Chavez-Garcia, A., Gómez, M., & Valle, P. (2015). Hernandez Morbilidad y mortalidad asociadas a gastrostomía endoscópica percutánea en el Hospital Juarez de Mexico. Rev Esp Méd quir, 20, 36–44.
2. Arvanitakis, M. (2021). Endoscopic management of enteral tubes in adults patients. Part 1: Definitions and indications. European Society of Gastrontestinal Endoscopy, 53.

3. Vazquez- Iglesias, J. S. A. (2009). Endoscopia Digestiva Diagnóstica y terapéutica. Editorial Médica panamericana, S. A. Madrid.
4. Gomez, S., Froilan, C., Martin, M., Suarez, J., & Segura, J. M. (2007). Gastrostomía endoscópica percutánea: nuestra experiencia. Servicio de Aparato Digestivo. Hospital Universitario La Paz. Madrid. España. Endocrinol Nutr, 54(7), 343–346.
5. Moran, B. J., & Taylor, M. (1990). Percutaneous endoscopic gastrostomy Br. Br. J. Surg, 77, 858–862.
6. Partovi, S., Li, X., Moon, E., & Thompson, D. (2020). Image guided percutaneous gastrostomy catheter placement: How we do it safely and efficiently. World Journal of Gastroenterology: WJG, 26(4), 383–392.
7. Gauderer, M. W., Ponsky, J. L., & Izant, R. J., Jr. (1980). Gastrostomy without laparotomy: a percutaneous endoscopic technique. Journal of Pediatric Surgery, 15(6), 872–875.
8. Divyanshoo, R. (2021). Safety of endoscopic gastrostomy tube placement compared with radiologic or surgical gastrostomy: nationwide inpatient assessment. Gastrointestinal Endoscopy, 93(5), 1077–1085.
9. Villalba, C. M., Vazquez, J. A., & Gallardo, F. (2018). Gastrostomia endoscópica percutánea. Indicaciones, cuidados y complicaciones. Med Clin (Barc).
10. Dietrich, C. G., & Schoppmeyer, K. (2020). Percutaneous endoscopic gastrostomy - Too often? Too late? Who are the right patients for gastrostomy? World Journal of Gastroenterology: WJG, 26(20), 2464–2471.
11. Hyeon Gang, M., & Kim, J. Y. (2014). Short-Term Complications of Percutaneous Endoscopic Gastrostomy according to the Type of Technique. Pediatr Gastroenterol Hepatol Nutr, 4, 214–222.
12. Piazze, A., Ormaechea, E., & Carbó, A. (2005). Endoscopia diagnóstica y terapéutica. Radiología. Anatomía Patológica. Oficina del Libro Fefmur . Montevideo, agosto de 2005
13. Sebastián, J. J. (2004). Gastrostomía endoscópica percutánea. Técnica e indicaciones. Endocrinologia y nutricion: organo de la Sociedad Espanola de Endocrinologia y Nutricion, 51(4), 158–162.
14. Rahnemai-Azar, A. A., Rahnemaiazar, A. A., Naghshizadian, R., Kurtz, A., & Farkas, D. T. (2014). Percutaneous endoscopic gastrostomy: indications, technique, complications and management. World Journal of Gastroenterology: WJG, 20(24), 7739–7751.
15. Stein, D., Moore, M., Hoffman, G., & Feuerstein, J. (s/f). Improving All Cause Inpatient Mortality After Percutaneous Endoscopic Gastrostomy.
16. Pih, G. Y., Na, H. K., Ahn, J. Y., Jung, K. W., Kim, D. H., Lee, J. H., Choi, K. D., Song, H. J., Lee, G. H., & Jung, H.-Y. (2018). Risk factors for complications and mortality of percutaneous endoscopic gastrostomy insertion. BMC Gastroenterology, 18(1), 101.
17. Schrag, S. P., Sharma, R., Jaik, N. P., Seamon, M. J., Lukaszczyk, J. J., Martin, N. D., Hoey, B. A., & Stawicki, S. P. (2007). Complications related to percutaneous endoscopic gastrostomy (PEG) tubes. A comprehensive clinical review. Journal of Gastrointestinal and Liver Diseases: JGLD, 16(4), 407–418.
18. Cyrany, J. (2016). Buried bumper syndrome: A complication of percutaneous endoscopic gastrostomy. World Journal of Gastroenterology: WJG, 22(2), 618.
19. Stenberg, K., Eriksson, A., Odensten, C., & Darehed, D. (2022). Mortality and complications after percutaneous endoscopic gastrostomy: a retrospective multicentre study. BMC gastroenterology, 22(1), 361. https://doi.org/10.1186/s12876-022-02429-0

Prevalence and Determinants of Hearing Loss in Patients with Chronic Rhinosinusitis in a Tertiary Hospital in Nigeria

Sanda AL, Adekoya VA, Sule SO, Dosumu AO & Nwawolo CC

Lagos State University Teaching Hospital

ABSTRACT

Background: Chronic rhinosinusitis is a common otorhinolaryngologic condition that is often encountered in daily practice. Nasal obstruction is the most disturbing symptom in patients with chronic rhinosinusitis, which could predispose them to otologic pathologies.

Aim: To assess the prevalence and determinants of hearing loss among patients with chronic rhinosinusitis in the Lagos State University Teaching Hospital.

Method: An analytical cross-sectional study which was conducted among 256 patients diagnosed with chronic rhinosinusitis in Lagos State University Teaching Hospital. Participants' audiological profiles were assessed by conducting Pure Tone Audiometry and Tympanometry. Data were analyzed with Statistical Package for Social Sciences version 26.0.

Keywords: chronic rhinosinusitis, hearing loss.

Classification: NLM Code: WV 140

Language: English

LJP Copyright ID: 392887

Great Britain Journals Press

London Journal of Medical & Health Research

Volume 25 | Issue 8 | Compilation 1.0

Prevalence and Determinants of Hearing Loss in Patients with Chronic Rhinosinusitis in a Tertiary Hospital in Nigeria

Sanda AL[α], Adekoya VA[σ], Sule SO[ρ], Dosumu AO[Ↄ] & Nwawolo CC[¥]

ABSTRACT

Background: Chronic rhinosinusitis is a common otorhinolaryngologic condition that is often encountered in daily practice. Nasal obstruction is the most disturbing symptom in patients with chronic rhinosinusitis, which could predispose them to otologic pathologies.

Aim: to assess the prevalence and determinants of hearing loss among patients with chronic rhinosinusitis in the Lagos State University Teaching Hospital.

Method: an analytical cross-sectional study which was conducted among 256 patients diagnosed with chronic rhinosinusitis in Lagos State University Teaching Hospital. Participants' audiological profiles were assessed by conducting Pure Tone Audiometry and Tympanometry. Data were analyzed with Statistical Package for Social Sciences version 26.0.

Result: The participants aged 40-49 years constituted the largest age group (30.1%), and most of them were female (69.5%). The prevalence of hearing loss among the participants was 40.2%. There were reduced odds for hearing loss among participants aged 20-29 years (AOR= 0.043, 95% C.I. = 0.012- 0.157), 30-39 years (AOR= 0.042, 95% C.I. = 0.010- 0.171) and 40-49 years (AOR= 0.075, 95% C.I. = 0.027- 0.209) compared with those age 60 years and above. Also there was reduced odds for hearing loss in male (AOR= 0.142, 95% C.I. = 0.057- 0.357), but those with facial pain had increased odds for hearing loss (AOR= 5.814, 95% C.I. =1.742- 19.231) and those with nasal polyp had increased odds for hearing loss (AOR= 2.134, 95% C.I. = 1.023- 4.451).

Conclusion: in this study, there was a high prevalence of hearing loss among patients with chronic rhinosinusitis, and its determinants were age, gender, facial pain and nasal polyps.

Keywords: chronic rhinosinusitis, hearing loss.

Author α σ ρ Ↄ ¥: Department of Otorhinolaryngology, Lagos State University Teaching Hospital.

I. INTRODUCTION

Chronic rhinosinusitis (CRS) is a common otorhinolaryngologic disease often encountered in ear, nose and throat (ENT) clinics. It usually lasts for at least 12 consecutive weeks with inflammation of the mucosa of the nose and paranasal sinuses.[1] CRS is not a life-threatening disease, but not all patients achieve control of their symptoms with medical or surgical intervention. Globally, the prevalence of CRS ranges between 5.5% and 27.1%.[2, 3-7] In Nigeria, it's prevalence ranges between 7.3% and 24.7%. It constitutes 78.2% of rhinologic cases seen in Nigerian tertiary hospitals.[8-10] Furthermore, studies have elucidated the high economic burden and the debilitating social health impact CRS confers on those who suffer from it.[11,12] It has been reported that in patients with CRS, though the main disturbing symptom is nasal obstruction, this could predispose the individuals to otologic pathologies. These otologic pathologies have been attributed to the tendency of patients with CRS to develop Eustachian tube dysfunction (ETD).[13] Other proposed mechanism includes the post nasal drip of mucus that causes inflammation / oedema of the Eustachian tube opening in the nasopharynx. Chronic ETD can result in reduced middle ear ventilation and other pathologies. A study by Li et al on hearing loss among patients

London Journal of Medical & Health Research

with CRS concluded that, in addition to conductive hearing loss, there was sensorineural hearing loss among patients with CRS. The study attributed their observation to immunoreactivity in the inner ear of patients with CRS.[14] Sandi et al also found both conductive and sensorineural hearing loss among patients with Allergic rhinitis.[15] There is a paucity of research studies on the hearing loss among patients with Chronic Rhinosinusitis (CRS) in Nigeria. This study is aimed at assessing the prevalence and determinants of hearing loss among patients with CRS in a tertiary hospital in Nigeria. The outcome of this study will contribute to the body of knowledge on the management of hearing loss in patients with CRS.

II. MATERIALS AND METHODS

Study Area: This study was conducted in the ENT department of Lagos State University Teaching Hospital (LASUTH), Ikeja, Lagos. The facility is one of the tertiary hospitals in Nigeria. It is expected to attend to the medical needs of an estimated 20 million residents alongside other hospitals within Lagos state. There are 750 beds in the facility, although it is still expanding with ultra-modern equipment.

Study Design and Population: The study was an analytical cross sectional study. The eligible participants were patients diagnosed with chronic rhinosinusitis with or without nasal polyps based on clinical features, nasoendoscopy and/or computerized tomography (CT) scan findings. All participants were 18 years and above.

Ethical Approval and Consent: Ethical approval for this research was obtained from the Health Research Ethical Committee of Lagos State University Teaching Hospital. All participants gave their Informed consent, and their information was kept confidential.

Sample and Data collection: Sample participants consist of 256 patients with chronic rhinosinusitis with or without nasal polyps. A proforma was administered to the participants by the researcher to collect their data. Thereafter, otological examination was done. Those with wax in the ear canal were syringed. Pure Tone Audiometry, and Tympanometry were then carried out on them.

Pure Tone Audiometry: Hearing assessment was performed using a calibrated Amplivox audiometer (United Kingdom) with well-fitting earphones and a bone vibrator. Participants were seated in a soundproof booth and instructed to press a response button whenever they perceived a tone. Air-conduction thresholds were obtained using the Hughson–Westlake ascending method, testing one ear at a time. Pure tones from 250Hz in octave spacing to 8000Hz were delivered to the tested ear. Each tone was initially delivered above the presumed threshold, then reduced in 10 dB steps until muffled, and subsequently increased in 5 dB steps until a response was given. The process was repeated until a stable threshold (defined as the level at which the participant responded on three occasions) was determined. The procedure continued until a single hearing level at which the participant responds thrice was obtained. For bone conduction audiometry, the vibrator was placed on the mastoid of the test ear, and pure tones between 250 Hz and 4000 Hz were presented using the same procedure. Masking was applied to the non-test ear to prevent crossover responses. Thresholds were plotted on an audiogram, and the pure-tone average (PTA) was calculated at 500 Hz, 1000 Hz, 2000 Hz, and 4000 Hz. Hearing level was classified according to the World Health Organization (2008) criteria, ranging from no impairment to profound impairment.

Tympanometry: The Amplivox otowave 102A Tympanometer from Amplivox United Kingdom was used to conduct Tympanometry. Each ear was individually tested using a probe of appropriate size, with a tone of 220Hz delivered. Tympanograms obtained for each ear of the participant were categorised as Type A (normal), Type As (low compliance at ambient pressure), Type Ad (increased compliance at ambient pressure), Type B (no change in compliance with pressure change), and Type C (maximum compliance at negative pressure).

Data Analysis: Data analysed with Statistical Package for Social Sciences (SPSS) version 26.0.

The result was presented in tables, bar charts and pie chart. The determinants of hearing loss in CRS were identified with binary logistic regression. The level of statistical significance was set at $P < 0.05$.

III. RESULT

A total of 256 participants with chronic rhinosinusitis were recruited for the study. The participants aged 40-49 years constituted the largest age group (30.1%), and most of them were female (69.5%). Most of them were traders (27.7%), married (62.9%) and had secondary education (64.5%) (Table 1).

Table 1: Socio-Demographic Characteristics of the Study Participants

Variables	Frequency, n=256	Percent (%)
Age group (years)		
<20	12	4.7
20- 29	42	16.4
30-39	44	17.2
40-49	77	30.1
50-59	27	10.5
≥60	54	21.1
Gender		
Male	78	30.5
Female	178	69.5
Occupation		
Trader	71	27.7
Artisan	20	7.8
Civil servant	58	22.7
Private firm employee	50	19.5
Retired	16	6.3
Student	28	10.9
Unemployed	13	5.1
Marital status		
Single	67	26.2
Married	161	62.9
Divorced/separated	7	2.7
Widow/widower	21	8.2
Education		
None	10	3.9
Primary	25	9.8
Secondary	165	64.5
Tertiary	56	21.8

The most common clinical presentations were mucopurulent discharge (98.4%) and nasal congestion (85.2%). Some had fatigue (77.0%), headache (67.2%), hyposmia/anosmia (62.1%), dental pain (47.7%), nasal polyp (40.6%) and ear pain (34.8%) while a few had halitosis (20.3%) and facial pain (17.2%) (Figure 1).

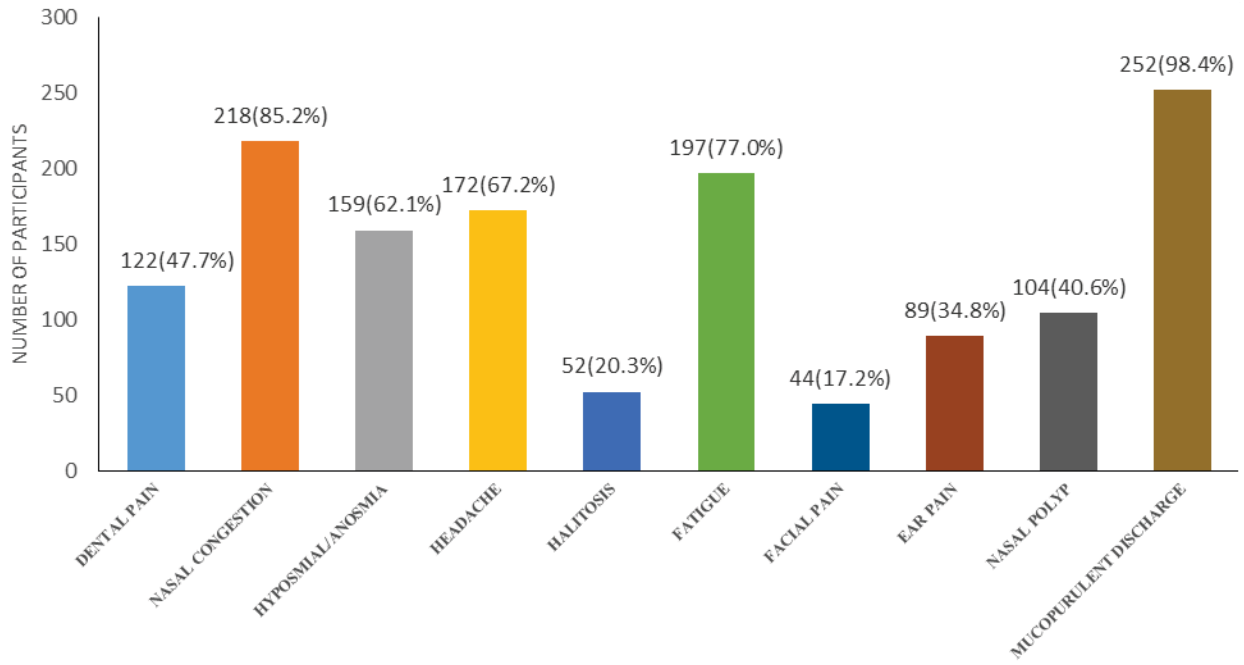


Figure 1: Clinical Presentation among Study Participants

The prevalence of hearing loss among the participants was 40.2% (Figure 2).

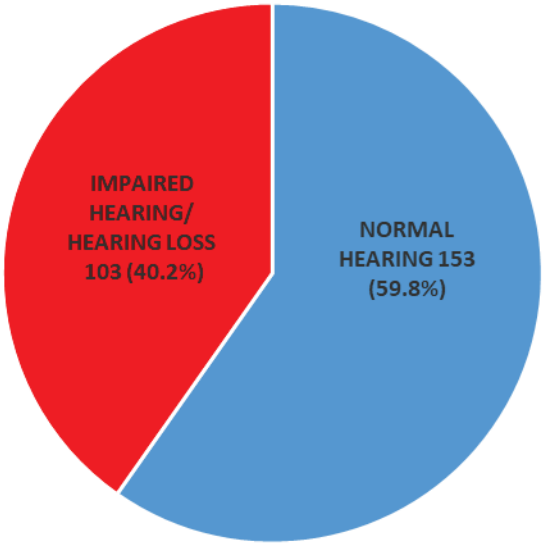


Figure 2: Prevalence of Hearing Loss Among Study Participants

The most common hearing loss was sensorineural (76.7%), some had mixed hearing loss (17.5%) while few had conductive hearing loss (5.8%) (Figure 3).

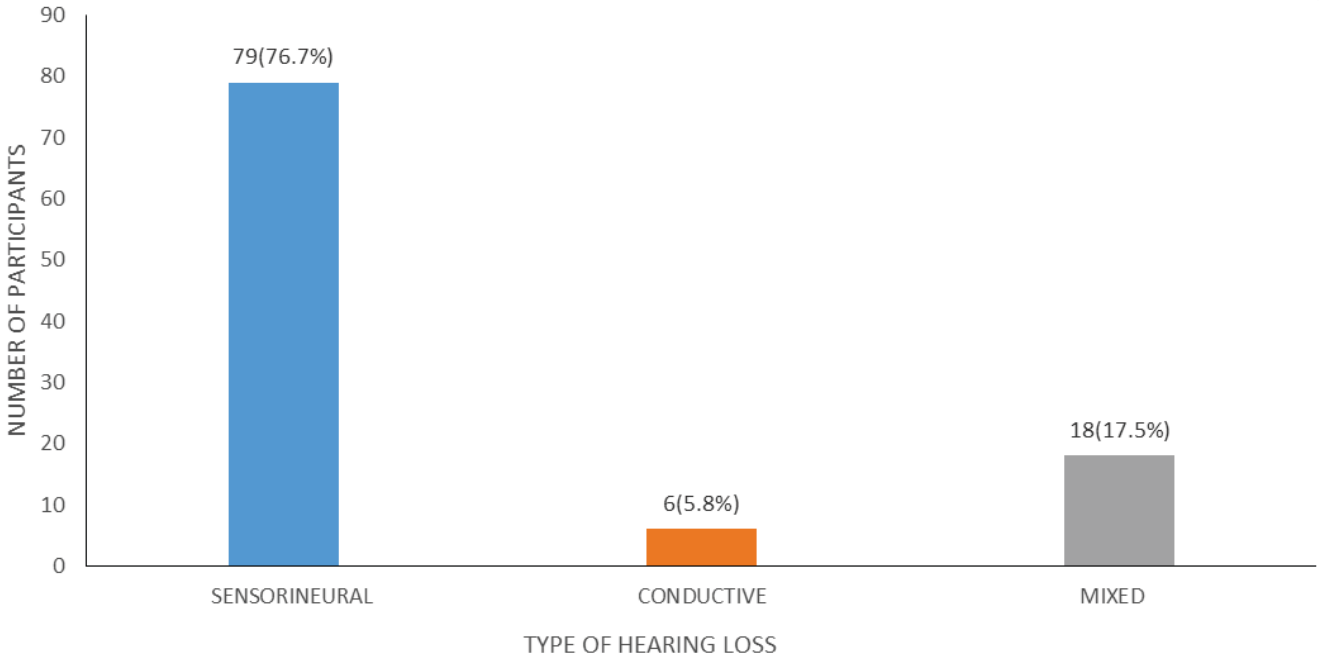


Figure 3: Types of Hearing loss among Study Participants

Majority of the participants had type A tympanometry in right and left ears (80.5% vs 85.5%), few had Ad (5.5% vs 3.9%), As (4.3% vs 3.1%), B (5.5% vs 2.7%) and C (4.3% vs 4.7%) as shown in table 2.

Table 2: Tympanometry Findings among Study Participants

Tympanometry	Right Ear	Left Ear
A	206(80.4)	219(85.6)
Ad	14(5.5)	10(3.9)
As	11(4.3)	8(3.1)
B	14(5.5)	7(2.7)
C	11(4.3)	12(4.7)

From the bivariate analysis, the significant determinants of hearing loss among the study participants were age group, gender, facial pain, fatigue, dental and ear pain. In contrast, multivariate analysis revealed age group, gender, facial pain and nasal polyp as significant determinants of hearing loss. There was reduced odds for hearing loss among participants aged 20-29 years (AOR= 0.043, 95% C.I= 0.012-0.157), 30-39 years (AOR= 0.042, 95% C.I= 0.010- 0.171) and 40-49 years (AOR= 0.075, 95% C.I= 0.027- 0.209) when compared with those that were 60 years and above. Also there was reduced odds for hearing loss in male (AOR= 0.142, 95% C.I= 0.057- 0.357) compared with female, those with facial pain had increased odds for hearing loss (AOR= 5.814, 95% C.I=1.742-19.231) compared with those that did not have facial pain while those that with nasal polyp had increased odds for hearing loss (AOR= 2.134, 95% C.I= 1.023-4.451) (Table 3).

Table 3: Determinants of Hearing Loss among the Study Participants

Variables	COR	95% C.I	P value	AOR	95% C.I	P value
Age group (years)						
<20	0.000	0.000	0.998	0.000	0.000	0.998
20- 29	0.071	0.026-0.191	<0.001*	0.043	0.012- 0.157	<0.001*
30-39	0.051	0.018- 0.141	<0.001*	0.042	0.010- 0.171	<0.001*
40-49	0.109	0.047- 0.252	<0.001*	0.075	0.027- 0.209	<0.001*

Variables	COR	95% C.I	P value	AOR	95% C.I	P value
50-59	0.331	0.118- 0.926	0.035*	0.821	0.238- 2.834	0.755
≥60	Reference			Reference		
Gender						
Male	0.395	0.219- 0.710	0.002*	0.142	0.057-0.357	<0.001*
Female	Reference			Reference		
Dental pain						
Present	1.946	1.170- 3.236	0.010*	1.282	0.580- 2.833	0.540
Absent	Reference			Reference		
Nasal congestion						
Present	2.083	0.964- 4.501	0.062	2.320	0.713- 7.545	0.162
Absent	Reference			Reference		
Halitosis						
Present	0.598	0.312-1.146	0.121	1.241	0.507- 3.038	0.637
Absent	Reference			Reference		
Fatigue						
Present	1.914	1.020- 3.593	0.043*	1.385	0.600- 3.202	0.446
Absent	Reference			Reference		
Facial pain						
Present	3.650	1.621- 8.264	0.002*	5.814	1.742- 19.231	0.004*
Absent	Reference			Reference		
Ear pain						
Present	2.639	1.502- 4.630	0.001*	1.292	0.602- 2.770	0.511
Absent	Reference			Reference		
Nasal polyp						
Present	1.414	0.851- 2.348	0.182	2.134	1.023- 4.451	0.043*
Absent	Reference			Reference		

**significant, COR- crude odds ratio, AOR- adjusted odds ratio, C.I. - confidence interval*

IV. DISCUSSION

This study assessed the prevalence and determinants of hearing loss among patients with chronic rhinosinusitis (CRS). The finding of this study showed that hearing loss among patients with CRS was higher than the global prevalence of hearing loss of 19.3%.[16] The overall prevalence of hearing loss in Mahabubnagar district, Telangana state, India is 8.9%, while disabling hearing loss was 4.5%.[17] The prevalence of hearing loss was 25.48% in a study conducted in Iraq.[18] In a population-based survey from Gao'an county, Jiangxi province, China reported, a hearing loss prevalence of 53.2%.[19] Many population-based investigations from Cameroon reported that the prevalence of hearing impairment ranges from 0.9 to 3.6%.[20] Hearing loss affects 23% of population in United States of America (USA).[21] The present study reported a prevalence of hearing impairment of 40.2% among patients with CRS, a value lower than 60% hearing impairment reported in previous study among patients with allergic rhinitis in India.[22] The difference in the prevalence between the two studies might be attributable to variation in the distribution of the demographic of the study populations and sample size of the studies. A study carried out by Adeyemi et al, looking at hearing loss in patients with allergic rhinitis reported a prevalence of 24.2% in their study. The latter study was conducted among children aged 4 to 16 years, thus this might be responsible for the lower burden of hearing loss.[23] The high prevalence of hearing loss among participants in this study might be due to the morphological and/or functional abnormalities of the Eustachian tubes caused by inflammation and the activation of inflammatory mediators in CRS. Retrograde inflammation of the middle ear can result in conductive deafness.[24] A population-based study found a correlation between CRS and sudden sensorineural hearing loss.[25] It has been suggested that CRS can potentially result in sensorineural hearing loss by impairing inner ear function by releasing different regional cytokines. There are lots of complement factors, lymphocytes, and macrophages in the endolymphatic sac. The cytokines and adhesion

molecules that are produced are crucial for the inner ear's immunological responses. Tumor necrosis factor alpha (TNF-α), generated by activated macrophages and lymphocytes in response to cross-antigens produced by the pathogenic microorganism, and tissues in the endolymphatic sac during nasal cavity and paranasal sinus infection can boost immune response.[26,27] Tumor necrosis factor alpha can create an aberrant inner ear microcirculation by activating the sphingosine 1-phosphate signaling system.[28] Tumor necrosis factor alpha level has been shown to be significantly associated with the result of sensorineural hearing loss in idiopathic sudden sensorineural hearing loss (ISSNHL), according to an analysis of blood inflammatory variables.[29] Treatment with TNF-α inhibitors may improve ISSNHL.[29]

In this study, age, gender, facial pain and nasal polyp were significant determinants of hearing loss. This finding is in line with Tsimpida et al, in a cross-sectional study of the English Longitudinal Study of Ageing (ELSA) that reported age, gender and other demographic characteristics as factors associated with the likelihood of HL.[30] The trajectory of hearing loss in this study and latter study increased with the increase in age because more hearing loss was observed among older individuals. However, the odds of hearing loss were lower in men in this study but higher in men in the latter study. Kerschaver et al, also observed more hearing loss among male than female individuals.[31] Facial pain and nasal polyps were clinical presentations in chronic rhinosinusitis patients associated with hearing loss in this study. These two presentations can be linked to roles of infection and allergy in the pathophysiology of CRS.[32] Allergic reactions could impede the nasal mucociliary function, resulting in CRS.[33] Numerous immunity-related plasma cells, mast cells, and other tissue constituents that can generate lysosomes, leukocytes with the capacity to phagocytose and fibrinolyze, and myoblasts with reparative properties are found in the nasal mucosa, lamina propria, and submucosal layer.[34] Sensorineural hearing loss can be caused by allergic rhinitis as a result of an immune response in the inner ears.[26,35,36]

In conclusion, the prevalence of hearing loss was high in patients with CRS. Majority of the hearing loss was sensorineural hearing loss. The determinants of hearing loss were age group, gender, dental pain and nasal polyps. Based on these findings, it is advisable that ENT specialists screen patients with CRS for hearing loss and provide timely interventions to prevent potential complications.

REFERENCES

1. Fokkens WJ, Lund VJ, Mullol J, Bachert C, Alobid I, Baroody F, Cohen N, Cervin A, Douglas R, Gevaert P, Georgalas C, Goossens H, Harvey R, Hellings P, Hopkins C, Jones N, Joos G, Kalogjera L, Kern B, Kowalski M, Price D, Riechelmann H, Schlosser R, Senior B, Thomas M, Toskala E, Voegels R, Wang de Y, Wormald PJ. European position paper on rhinosinusitis and nasal polyps. Rhinol Suppl 2012; 23: 3– 298.
2. Hamilos DL. Chronic rhinosinusitis: Epidemiology and medical management. The Journal of Allergy and Clinical immunology. 2011; 128(4):693- 707.
3. Hastan D, Fokkens WJ, Bachert C, Newson RB, Bislimovska J, Bockelbrink A, Bousquet PJ, Brozek G, Bruno A, Dahlén SE, Forsberg B, Gunnbjörnsdóttir M, Kasper L, Krämer U, Kowalski ML, Lange B, Lundbäck B, Salagean E, Todo-Bom A, Tomassen P, Toskala E, van Drunen CM, Bousquet J, Zuberbier T, Jarvis D, Burney P. Chronic rhinosinusitis in Europe–an underestimated disease. A GA(2)LEN study. Allergy 2011; 66: 1216–1223. doi: 10.1111/j.1398-9995.2011.02646.x.
4. Thilsing T, Rasmussen J, Lange B, Kjeldsen AD, Al-Kalemji A, Baelum J. Chronic rhinosinusitis and occupational risk factors among 20- to 75-year-old Danes-A GA(2) LEN-based study. Am J Ind Med 2012; 55: 1037– 1043.
5. Pilan RR, Pinna FR, Bezerra TF, Mori RL, Padua FG, Bento RF, Perez-Novo C, Bachert, Voegels RL. Prevalence of chronic

rhinosinusitis is sin Sao Paulo. Rhinology 2012; 50: 129– 138.
6. Kim YS, Kim NH, Seong SY, Kim KR, Lee GB, Kim KS. Prevalence and risk factors of chronic rhinosinusitis in Korea. Am J Rhinol Allergy 2011; 25: 117– 121.
7. Blackwell DL, Lucas JW, Clarke TC. Summary health statistics for U.S. adults: national health interview survey, 2012. Vital Health Stat 2014; 10: 1– 161.
8. Fasunla AJ, Nwaorgu OGB. Adult Chronic Rhinosinusitis: Spectrum of Clinical Features in a Tertiary Health Institution and Literature Review. East Cent Afr J Surg. 2011; 16(1): 12-18.
9. Iseh KR, Makusidi M. Rhinosinusitis: a retrospective analysis of clinical pattern and outcome in north western Nigeria. Annals of African medicine. 2010; 9(1).
10. Adegbiji AW, Aremu SK, Akanbi GO, Olatoke F, Ajite KO. Clinicoepidemiological Pattern of Rhinosinusitis in a University Hospital in Ekiti, Nigeria. Glob J Oto 2018; 12(4): 00103 - 00108.
11. Anand VK. Epidemiology and economic impact of rhinosinusitis. Ann Otol Rhinol Laryngol Suppl 2004; 193: 3– 5.
12. Benninger MS. Rhinosinutis. In. Gleson M, Browning GG, Burton MJ, Clarke R. Editors. Scott-Brown's Otorhinolaryngology, Head and Neck Surgery. 7th Ed. Vol 2, London: Hodder Anorld; 2008: 1439- 1447.
13. Smith ME, Tysome Matthew E, Smith JR, Smith M. Tests ofEustachian tube function: a review. Clin Otolaryngol 2015;40:300–11.
14. Lin X, Shan X, Lin S, Shu B, Wang Y, Xiao W. "Is Sensorineural Hearing Loss Related to Chronic Rhinosinusitis Caused by Outer Hair Cell Injury?" Medical Science Monitor. 2019; 25: 627–636.
15. Sahni D, Verma P, Bhagat S , Sharma V. Hearing Assessment in Patients of Allergic Rhinitis: Indian J Otolaryngol Head Neck Surg. 2020; 74: 125–131.
16. Haile LM, Kamenov K, Briant PS, Orji AU, Steinmetz JD, Abdoli A, et al. Hearing loss prevalence and years lived with disability, 1990–2019: findings from the Global Burden of Disease Study 2019. Lancet. 2021; 397(10278):996–1009.
17. Bright T, Mactaggart I, Kuper H, Murthy GV, Polack S. Prevalence of hearing impairment in Mahabubnagar district, Telangana state. India Ear Hear. 2019; 40(1): 204– 212
18. Al-Ani RM, Jamal KK, Fakhri FW, et al. Prevalence of hearing loss among patients attending the private otolaryngology clinic, Ramadi city, Anbar, Iraq. Egypt J Otolaryngol. 2024; 40: 71.
19. Bright T, Shan X, Xu J, Liang J, Xiao B, Ensink R, et al. Field-testing of a rapid survey method to assess the prevalence and causes of hearing loss in Gao'an, Jiangxi province. China Arch Public Heal. 2020; 78:1–15
20. Tingang WE, Noubiap JJ, Fokouo JV, Oluwole OG, Nguefack S, Chimusa ER et al Hearing impairment overview in Africa: the case of Cameroon. Genes (Basel) 2020; 11(2): 233.
21. Goman AM, Lin FR. Prevalence of hearing loss by severity in the United States. Am J Public Health. 2016; 106(10): 1820–1822.
22. Acharya S, Bepari K, Biswal S, Dash S, Agrawal P, Mohapatra D, et al. Study of incidence of sensorineural hearing loss in allergic rhinitis Int J Otorhinolaryngol Head Neck Surg 2022; 8: 228-31.
23. Adeyemo A, Eziyi J, Amusa Y, Ameye S. Hearing profile in children with allergic rhinitis. Adv Arab Acad Audio-Vestibul J. 2017; 4:10–13
24. Tomiyama S, Harris JP. The role of the endolymphatic sac in inner ear immunity. Acta Otolaryngol. 1987; 103(3–4): 182–88.
25. Hung SH, Lin HC, Kao LT. Sudden sensorineural hearing loss is associated with chronic rhinosinusitis: Population-based study. J Laryngol Otol. 2016; 130(6): 521–25.
26. Lasisi AO, Abdullahi M. The inner ear in patients with nasal allergy. J Natl Med Assoc. 2008; 100(8): 903–5.
27. Kojima Y, Ito S, Furuya N. Hearing improvement after therapy for hyperlipidemia in patients with chronic-phase sudden deafness. Ann Otol RhinolLaryngol. 2001; 110(2): 105–8.
28. Scherer EQ, Yang J, Canis M. TNFα enhances microvascular tone and reduces blood flow in

the cochlea viaenhanced S1P signaling. Stroke. 2010; 41(11):2618–24.
29. Demirhan E, Eskut NP, Zorlu Y. Blood levels of TNF-alpha, IL-10, and IL-12 in idiopathic sudden sensorineural hearing loss. Laryngoscope. 2013; 123(7):1778–81.
30. Tsimpida D, Kontopantelis E, Ashcroft D, et al Socioeconomic and lifestyle factors associated with hearing loss in older adults: a cross-sectional study of the English Longitudinal Study of Ageing (ELSA) BMJ Open 2019;9:e031030.
31. Van Kerschaver E, Boudewyns AN, Declau F, Van de Heyning PH, Wuyts FL. Socio-demographic determinants of hearing impairment studied in 103 835 term babies, European Journal of Public Health. 2013; 23(1): 55–60.
32. Harris JP, Woolf NK, Ryan AF. Elaboration of systemic immunity following inner ear immunization. Am JOtolaryngol. 1985; 6(3):148–52.
33. Wu HY, Nikolova EB, Beagley KW, Russell MW. Induction of antibody-secreting cells and T-helper and memorycells in murine nasal lymphoid tissue. Immunology. 1996; 88(4): 493–500.
34. Yan Z, Wang JB, Gong SS, Huang X. Cell proliferation in the endolymphatic sac in situ after the rat Waldeyerring equivalent immuno stimulation. Laryngoscope. 2003; 113(9): 1609 –14.
35. Lombardi C, Tansini A, Passalacqua G. Seasonal sensorineural hearing loss associated with allergic rhinitis: A case report. J Allergy Clin Immunol. 2006; 117(2): 468–69.
36. Singh S, Nagarkar AN, Bansal S. Audiological manifestations of allergic rhinitis. J Laryngol Otol.2011; 125(9): 906–10.

This page is intentionally left blank

Effect of using a Composition of 4 Essential Oils on Self-Esteem, Training Quality and Pain Score in Athletes from the Moroccan National *Poomsae* Team

Madiha Bahouq, Hanane Bahouq, Ali Amassnaou & Driss Elhilali

University Ibn Tofail

ABSTRACT

During training and competitions, athletes face physical factors, including pain, fatigue and exhaustion, added to psychological factors, including negative vibes and mental pressure. Recovery is a key function; it is a step aimed at restoring athletes' physical condition to its normal pre-competition state. Essential oils have shown their positive effect in improving sports performance by modulating psychological states, improving alertness and reducing pain, physical and mental fatigue. This study aims to determine the effect of using a mixture of 4 essential oils on training quality, self-confidence, fatigue and pain in athletes of the Moroccan national poomsae team. Other factors were studied: self-esteem, depression, insomnia and back pain. The results showed a significant effect of using Essential oils on all factors studied.

Keywords: essential oils, moroccan poomsae team, pain, fatigue, training quality.

Classification: NLM Code: QV 740

Language: English

LJP Copyright ID: 392888

Great Britain Journals Press

London Journal of Medical & Health Research

Volume 25 | Issue 8 | Compilation 1.0

Effect of using a Composition of 4 Essential Oils on Self-Esteem, Training Quality and Pain Score in Athletes from the Moroccan National *Poomsae* Team

Madiha Bahouq[α], Hanane Bahouq[σ], Ali Amassnaou[ρ] & Driss Elhilali[Ꞷ]

ABSTRACT

During training and competitions, athletes face physical factors, including pain, fatigue and exhaustion, added to psychological factors, including negative vibes and mental pressure. Recovery is a key function; it is a step aimed at restoring athletes' physical condition to its normal pre-competition state. Essential oils have shown their positive effect in improving sports performance by modulating psychological states, improving alertness and reducing pain, physical and mental fatigue. This study aims to determine the effect of using a mixture of 4 essential oils on training quality, self-confidence, fatigue and pain in athletes of the Moroccan national poomsae team. Other factors were studied: self-esteem, depression, insomnia and back pain. The results showed a significant effect of using Essential oils on all factors studied.

Keywords: essential oils, moroccan poomsae team, pain, fatigue, training quality.

Author α: University Ibn Tofail, laboratoty of biotechnology and plant protection, Kenitra, Moroccan Royal Federation of Taekwondo, Rabat, Morocco.
σ: University Ibn Tofail, laboratoty of biometry, Kenitra, Hospital Azemmouri, Kenitra, Morocco.
ρ Ꞷ: Moroccan Royal Federation of Taekwondo, Rabat, Morocco.

I. INTRODUCTION

Taekwondo (Poomsae) is a martial art that combines different components of other oriental martial arts. Poomsae is played with the hands and legs. The legs contain a large group of muscles, which can provide a more powerful impact [1,2]. The technical training of the Poomsae athlete aims to improve the techniques of movements special to this sport. During general technical training, the athlete rebuilds the funds of mobility and impulse which are essential to him in the practice of Poomsae. During specific technical exercises, the athlete aims to master the particular techniques and deepen his sports specialization, resulting in Developing the necessary skills and abilities [3-5]. The techniques used in Poomsae are subdivided according to the following notions: positions, movements, strikes, acrobatic and complicated defense actions and coordination actions [2,4].

Taekwondo is a sport that requires from athletes to exert effort and explosive strength in a short time. It may cause a range of lower extremity injuries and fatigue, thereby reducing athletes' achievement. In extreme cases, an injured athlete will be in the possible need to abandon his professional activity [6].

Before, during and after competition or training, athletes must deal with physical factors, including fatigue, and psychological factors, including negative emotions and mental pressure [7]. Athletes' adaptation skills are a determining factor in their performance, knowing that these skills have an influence on their personal and professional lives [8]. The state of muscle fatigue is determined as the capacity of each muscle fiber to contract its limit and results from excessive physical activities or cyclic exercises [7].

Recovery is an important phase aimed at restoring athletes' physical condition to its normal state before competition or training [9].

Essential oils have shown abilities to improve athletic performance by controlling psychological states, increasing alertness, and reducing physical and mental fatigue [10]. Athletes can use these oils for curative and preventive purposes.

In aromatherapy, essential oils used as therapeutic agents are highly concentrated compounds extracted from stems, fruits, flowers, leaves, roots, or resins [11]. The inhalation of volatile plant materials has been used for centuries in complementary and alternative therapies with the aim of balancing the mental and physical health of humans. Essential oil or also called volatile oil is a concentrated hydrophobic liquid made up of volatile compounds extracted from plants. Application of essential oils is done in 3 ways: by inhalation through the olfactory system and skin, by topical application of essential oil to the skin, and by consumption, including drinking [12]. In general, essential oils contain chemical compounds that have either stimulating or sedative effects depending on their chemical compounds working as a whole. The chemical compounds contained in essential oils include monoterpenes, sesquiterpenes, ethers, alcohols, ketones, phenols, acids, esters and aldehydes [13].

Volatile particles can pass through various parts of the body, by diffusion, via the respiratory system [14] and through oral consumption. Essential oils and their metabolites are absorbed and transported throughout the body via the bloodstream. Once the components of essential oils are in the body, they exert their effects through three different modes of action: biochemical (pharmacological), physiological and psychological [15].

These oils have properties that can be used in accelerating recovery by reducing the incidence of fatigue and boosting the energy level of the mind and body enhancing self-esteem and self-confidence of athletes. Thus, the therapeutic use of essential oils has become recognized as a valuable therapy aimed at improving sports performance and general well-being [16].

This study aims to determine the effect of using a mixture of 4 essential oils on training quality, self-confidence, fatigue and pain in athletes of the Moroccan national poomsae team. Other factors were studied: self-esteem, depression, insomnia and back pain.

II. MATERIALS AND METHODS

2.1 Materials

The choice of the national poomsae team was based on complaints made by players about pain felt before or after training sessions or after their performances in national or international events.

The choice of essential oils to use in this composition was following a series of consultations with a naturopath qualified in sports medicine and taking into account the health conditions of the athletes and their specificities.

The protocol of this study was to use the composition of the essential oils chosen in the form of a mixture of the dilution of the essential oils in an oil carrier. The mixture was used in the form of a delicate massage on the painful area 3 times a day for 2-3 days' maximum.

2.2 Methods

This study used an experimental design with a control group and pre-and post-test group. The sample consisted of 25 athletes. The essential oils used were marjoram sweet, rosemary, basil and chamomile roman blended in proportions of 2:3:1:1. They were mixed with a carrier oil composed of avocado oil (75%) and sesame oil (25%) and they were diluted to 5% after blending. The data were analysed using SPSS program.

2.3 Numeric Rating Scales

The numerical pain rating scale consists of a series of numbers rating the intensity of pain, usually from 0 to 10, with 0 meaning "no pain" and 10 "the worst pain imaginable" [17].

Fatigue numeric rating scale consists of a series of numbers rating the intensity of fatigue during exercise, typically from 0 to 10, with 0 meaning "no fatigue felt" and 10 meaning "tremendous difficulty continuing the exercise" [18].

Training quality and self-esteem by interrogating the athletes on their evaluation before and after using essential oils.

III. RESULTS

Table 1. shows the results of ANOVA analysis. ANOVA test analysis showed a significant difference between the two groups studied.

Table 1: Test Anova 1 Factor Analysis

		Sum of squares	ddl	Mean of squares	F	Signification
AGE	Inter-groupes	.000	1	.000	.000	1.000
	Intra-groupes	5153.333	22	234.242		
	Total	5153.333	23			
GENDER	Inter-groupes	.000	1	.000	.000	1.000
	Intra-groupes	5.833	22	.265		
	Total	5.833	23			
selef esteem	Inter-groupes	273.375	1	273.375	30.439	.000
	Intra-groupes	197.583	22	8.981		
	Total	470.958	23			
DEPRESSION	Inter-groupes	10.667	1	10.667	18.526	.000
	Intra-groupes	12.667	22	.576		
	Total	23.333	23			
BACK PAIN	Inter-groupes	3.375	1	3.375	33.000	.000
	Intra-groupes	2.250	22	.102		
	Total	5.625	23			
PAIN	Inter-groupes	54.000	1	54.000	66.000	.000
	Intra-groupes	18.000	22	.818		
	Total	72.000	23			
FATIGUE	Inter-groupes	66.667	1	66.667	50.000	.000
	Intra-groupes	29.333	22	1.333		
	Total	96.000	23			
Sleep perturbation	Inter-groupes	13.500	1	13.500	28.742	.000
	Intra-groupes	10.333	22	.470		
	Total	23.833	23			
TRAINING QUALITY	Inter-groupes	37.500	1	37.500	79.839	.000
	Intra-groupes	10.333	22	.470		
	Total	47.833	23			
SELF CONFIDENCE	Inter-groupes	18.375	1	18.375	47.097	.000
	Intra-groupes	8.583	22	.390		
	Total	26.958	23			

As shown on table 2, the normality test showed that the age and pain parameters follow the normal distribution, unlike the rest of the parameters studied. Thus, other tests are necessary.

Table 2: Normality Test Analysis

		Kolmogorov-Smirnov[a]			Shapiro-Wilk		
		Statistics	ddl	Signification	Statistics	ddl	Signification
Age/Eo Yes or No	14	,260	2				
	17	,260	2				
	20	,260	2				
	21	,260	2				
	22	,260	2				
	24	,319	6	,056	,683	6	,004
	28	,260	2				
	40	,260	2				
	56	,260	2				
	62	,260	2				
Gender/Eo Yes or No	Male	,332	14	,000	,646	14	,000
	Female	,329	10	,003	,655	10	,000
Self Esteem/Eo Yes or No	12	,307	4		,729	4	,024
	15	,385	3		,750	3	,000
Depression/Eo Yes or No	Sometimes	,360	7	,007	,664	7	,001
	Often	,455	8	,000	,566	8	,000
Back Pain/Eo Yes or No	Yes	,485	15	,000	,499	15	,000
	Light Pain	,319	6	,056	,683	6	,004
Fatigue/Eo Yes or No	Slithly Fatigue	,519	9	,000	,390	9	,000
Sleep Perturbation/Eo Yes or No	One Night	,504	7	,000	,453	7	,000
	2 Nights	,524	10	,000	,366	10	,000
Training Quality/Eo Yes or No	Acceptable Quality	,385	3		,750	3	,000
Self Confidence/Eo Yes or No	Acceptable	,435	7	,000	,600	7	,000
Pain/Eo Yes or No	Light Pain	,319	6	,056	,683	6	,004

Table 3 shows the analysis of parameters not following the normal law. Since the assumption of normality was not met, the Wilcoxon test was used. Thus, the significant effect of the use of essential oils is observed. The paired groups test (t test) will be carried out for the two parameters following the normality law as shown in table. 4.

	Eo Yes or No - Gender	Eo Yes or No - Selef Esteem 0-30	Eo Yes or No - Depression	Eo Yes or No - Back Pain Yes No	Eo Yes or No - Fatigue	Eo Yes or No - Sleep Perturbation	Eo Yes or No - Training Quality	Eo Yes or No - Self Confidence
Z	-,577[b]	-4.291[c]	-3.754[c]	-,655[c]	-4.319[c]	-2.914[c]	-3.976[c]	-4.041[c]
Asymptotic Signification (Bilateral)	,564	,000	,000	,513	,000	,004	,000	,000

a. Wilcoxon test
b. Based on negative ranks
c. Based on positive ranks

Table 4: Paired Samples t-test

		Paired Differences					T	Ddl	Sig. (Bilateral)
		Mean	Standard Deviation	Average Standard Error	95% Confidence Interval Of The Difference				
					Lower	Superior			
Paire 1	Age - Eo Yes or No	28,833	14,977	3,057	22,509	35,158	9,431	23	,000
Paire 2	Pain - Eo Yes or No	3,500	2,226	,454	2,560	4,440	7,702	23	,000

Similarly, the use of essential oils had a significant effect on age and pain between the two studied groups.

Aromatherapy significantly affected the studied parameters between the experimental groups.

The results showed that aromatherapy has major effects on decreasing pain and fatigue levels, increasing self-esteem, self-confidence and improving training quality. Based on our experiment's findings, we suggest that aromatherapy can be an effective alternative method to address the various types of stress and discomfort experienced by athletes before and after training sessions and competitions.

IV. DISCUSSION

The results showed that aromatherapy has major effects on decreasing pain and fatigue levels, increasing self-esteem, self-confidence and improving training quality. Based on our experiment's findings, we suggest that aromatherapy can be an effective alternative method to address the various types of stress and discomfort experienced by athletes before and after training sessions and competitions.

As a result, a positive effect of the 4 essential oils used on the pain and fatigue of Taekwondo athletes in Morocco is declared.

Rosemary, an aromatic plant whose scientific name is *Rosmarinus officinalis L.*, belonging to the *Lamiaceae* family. *R. officinalis L.* is a Mediterranean aromatic shrub well known for its evergreen leaves and medicinal properties. This particular variety is distinguished by its high content of cineole, a chemical compound also called eucalyptol, which gives it specific properties [19]. Rosemary has various pharmacological properties to treat diseases, including the treatment of Alzheimer's disease [20] and its hepatoprotective abilities [21]. Thanks to its analgesic and anti-inflammatory properties, rosemary essential oil is often used to treat muscle pain, joint pain and tension. Rosemary, especially in its cineole form, is an excellent adaptogen, it can help combat mental and physical fatigue, as well as stress. Rosemary essential oil can be extracted by steam distillation from fresh twigs

and leaves. A previous study by Sienkiewicz et al. [22] revealed that the main compounds of rosemary essential oil include *1,8-cineole* (46.4%), *camphor* (11.4%), and *α-pinene* (11.0%). in addition to some terpene compounds in small quantities (*Borneol, Linalool*, etc.). Rosemary essential oils can be extracted through steam distillations of twigs and fresh leaves.

Common sage or *Salvia officinalis* is one of the species of *Salvia*. Sage is well known for its medicinal properties and has been used since ancient times to treat various ailments. It contains essential oils, flavonoids, tannins, and phenolic acids, which give it powerful therapeutic properties [23]. A 2017 study reported that the main compounds in *Salvia officinalis* essential oil included *camphor* (25.14%), *α-thujone* (18.83%), *1,8-cineole* (14.14%) %) and *viridiflorol* (7.98%) [24]. The pharmacological properties of sage essential oil are antioxidant, anti-inflammatory, antimicrobial, anticancer, calming and anxiolytic and sage essential oil also serves as cleansing agents (antiseptic and antibacterial) [25].

In addition, sage essential oil appears to improve emotions and cognitive functions in humans. the results of the study by Moss et al. [26] revealed that sage essential oil improved mood and memory performance after sage essential oil inhalation compared to the control group without essential oil [26]. Gaballah and al., [27] measured the effect of sage consumption on the respiratory functions of football players. Researchers have suggested that sage essential oil promotes high-intensity, repeated exercise [28].

O. basilicum, Basil essential oil is known for its high content of phenolic and flavonoid components, including *chlorogenic acid, gallic acid, rutin, quercitrin, isoquercitrin, rosmarinic acid, caffeic* and *kaempferol* and other bioactive compounds, giving it a wide range of therapeutic properties. It is used for its anti-inflammatory, antibacterial, antifungal, calming, digestive, and antioxidant properties, and is often used in aromatherapy to treat various conditions, ranging from digestive disorders to stress and anxiety [29].

Basil oil (including sesame oil as a vehicle) has been specifically recommended for relieving joint pain [30, 31]. Research has demonstrated its excellent antioxidant properties [32], attributed to its high content of polyphenols and flavonoids [33]. Many studies have confirmed these anti-nociceptive [34, 35] and anti-inflammatory properties [36-38] of this medicinal plant.

Therefore, the topical application of basil oil thrice daily over a period of 4 weeks can effectively improve the clinical symptoms of knee osteoarthritis, which is considered an efficient method for managing this condition [39, 40].

The improvement in clinical symptoms of knee osteoarthritis suggests that the peripheral antinociceptive activity of the plant is associated with the inhibition of pain mediators such as prostaglandins [39, 40].

Chamomile nobile (L.) All. (Asteraceae), widely known as *Roman chamomile*, is a perennial herb native to southwest Europe, it is considered a medicinal plant and cultivated throughout Europe and also in Africa. The plant was given the name *"nobile"* (Latin, noble) for its greater therapeutic effectiveness than *Matricaria recutita L.* (German chamomile) [41]. The use of traditional *Roman chamomile* in medicine is especially linked to its supposed smooth muscle relaxing effect. Anti-inflammatory properties and heat shock protein stabilizing effects of the *flavonoids apigenin* and *quercetin,* as well as the anti-inflammatory properties of *α-bisabolol, guajazulene,* and *chamazulene* have been reported in preclinical studies [42-44].

The results of the study of *Roman chamomile (A. nobilis)* essential oil indicated that the volatile oils possessed high antioxidant activity [45] and it was in good agreement with its higher phenolic content. As revealed by mass spectrometry analysis, the potent antioxidant capacity of aqueous extracts of *A. nobilis* may result from the presence of *quinic* acid and *caffeic* acid derivatives [46].

In an open clinical study carried out on 54 patients suffering from chronic bronchial asthma,

A. nobilis showed anti-asthmatic effects, it induced a significant increase in the values of forced expiratory volume in the first second (FEV) and forced volume capacity (FVC) with a marked decrease in the frequency of asthma attacks [47]. Which can be helpful to athletes with special cases or to improve the VO2max (maximum oxygen consumption) capacities.

Jeong et al. (2000) reported that aromatherapy shortened the time needed for recovery by reducing the sensation of pain in the arms and legs. These effects are thanks to muscle relaxation. As a result, aromatherapy has been reported to improve athletic performance. Aromatherapy and acupressure to acupoints significantly reduced the creatine phosphokinase (CPK) levels [48].

Therefore, aromatherapy is known to alleviate symptoms related to imbalance in the autonomic nervous system [49]. With regard to the release mechanism of the stress hormone catecholamine, Langer (1980) reported that decreased stress and awakening were observed after simultaneously inhaling relaxation oil, which is made of lavender and clary sage known to reduce blood pressure and stress, and stimulation oil, which is made of lemon and rosemary. It can be inferred that inhaled aromatic oil scents affect the adrenal glands [50].

The results showed that aromatherapy using essential oils was the most effective method for reducing fatigue and lowering stress hormone levels [51].

Fatigue is reduced during exercise thanks to aromatherapy and essential oils. Although the participants exercised under the same conditions for the same duration and with the same intensity, they rated the exercise less difficult during the second experiment and reported that the time passed more quickly [52].

Participants showed an improvement in their feelings after exercise. This is an important issue in sports sciences and has been verified by numerous studies [53]. In other words, the improvement in a person's feelings when exercising will consequently result in the desire to continue exercising.

V. CONCLUSIONS

The results showed that aromatherapy has major effects on decreasing pain and fatigue levels, increasing self-esteem, self-confidence and improving training quality. Based on our experiment's findings, we suggest that aromatherapy can be an effective alternative method to address the various types of stress and discomfort experienced by athletes before and after training sessions and competitions.

As a result, a positive effect of the 4 essential oils used on the pain and fatigue of Taekwondo athletes in Morocco is declared.

Aromatherapy is a booster for maintaining the four components of sports performance. Athletes can enjoy the benefits of essential oils, including healthy respiratory function, clear breathing, better sleep quality, more energy, rapid recovery, reduced muscle and joint pain, increased concentration and a healthy emotional state. Essential oils appear to be very effective in reducing physical and mental fatigue, promoting sports performance and promoting the recovery of athletes. *Rosmarinus officinalis L.* (rosemary), *basilicum*, Basil essential oil, and *Salvia officinalis L.* (sage) accelerate sports recovery and relieve fatigue while improving physical performance and concentration. *Roman chamomile* essential oil improves physical performance while promoting sports performance and physical functions. Therefore, athletes benefit from applying essential oils to help them maintain and improve their overall athletic performance. There are still other essential oils which have not yet been the subject of study of their effects on sports performance. Future research is needed to apply their benefits to sports performance.

Conflicts of Interest: The authors declare no conflict of interest.

ACKNOWLEDGMENTS

The authors would like to thank the research coordinators at the recruitment center especially Madiha Bahouq, Hanane Bahouq, Ali Amassnaou and Driss Elhilali for their expertise and technical contribution.

Declarations

The authors declare that this work is not part of any project and has not received any funding.

Funding

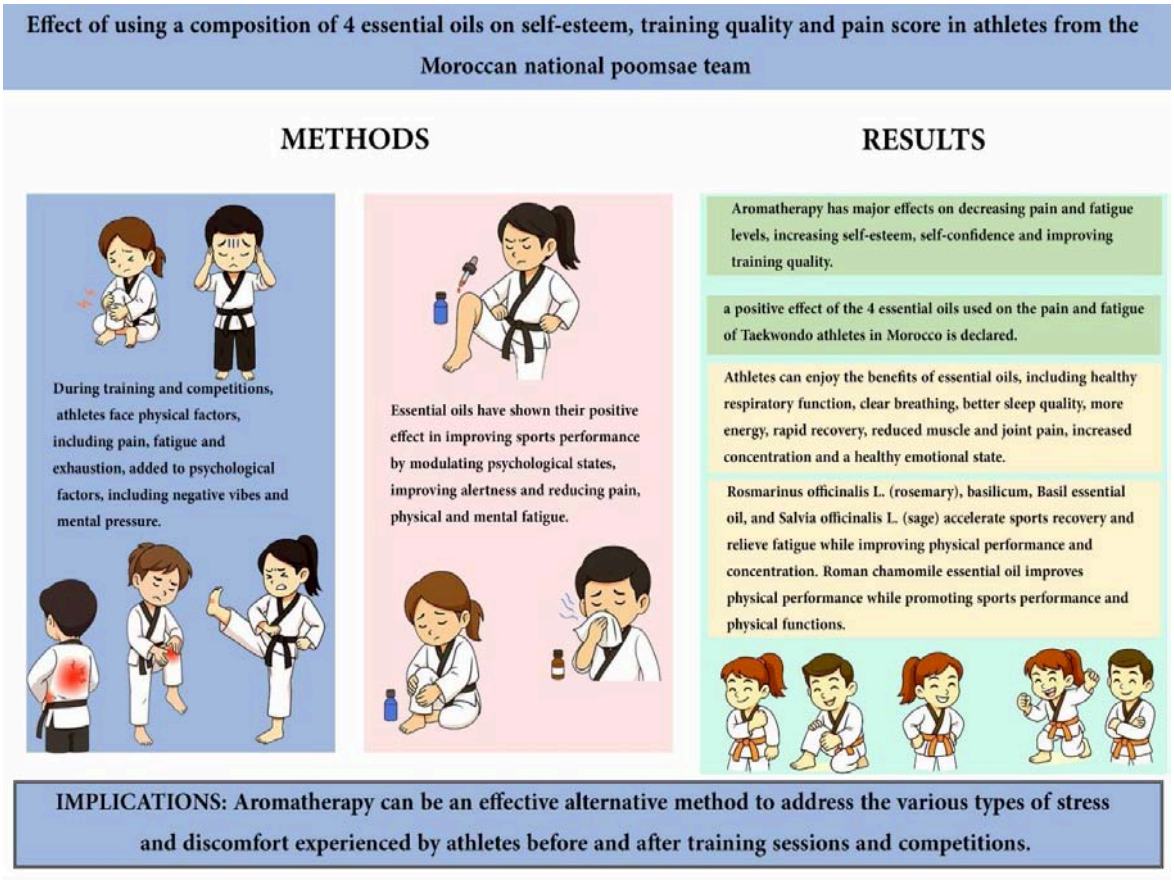
not applicable.

REFERENCES

1. Kim S, Lee KM, Jeong KH. *Taekwondo Kyorugi*. Turtle Press; 1999.
2. Southwick RA. *The Poomsae of Taekwondo*. 2005.
3. Koshcheev AS. Pre-competition improvement physical training of mass-class taekwondo fighters specialized-basic stage. In: I International Scientific and Practical Internet Conference: Problems and Prospects for the Development of Science at the Beginning of the Third Millennium in the Countries of Europe and Asia. Pereyaslav-Khmelnytskyi; 2014: 250.
4. Chun R, Wilson PH. *Tae Kwon Do: The Korean Martial Art*. 1st ed. Harper Collins Publishers; 1976.
5. Price RG, Haselow-Dulin M. *The Ultimate Guide to Weight Training for Martial Arts*. Price World Enterprises; 2003.
6. Kim HC, Kim YJ. A research into injuries to Taekwondo trainees during exercise- Focusing on South Chungcheong. *J Digit Converg*. 2013; 11(4): 415-430.
7. Manion AF, Connolly B, Wood K, et al. The use of surface EMG power spectral analysis in the evaluation of back muscle function. *J Rehabil Res Dev*. 1997; 34: 427-439.
8. Cosma G, Chiracu A, Stepan R, et al. Impact of coping strategies on sport performance. *J Phys Educ Sport*. 2020; 20(3): 1380-1385.
9. Peiffer JJ, Abbiss CR, Watson G, Nosaka K, Laursen PB. Effect of cold-water immersion.
10. Kennedy DO. Phytochemicals for improving aspects of cognitive function and psychological state potentially relevant to sports performance. *Sports Med*. 2019; 49(1): 39-58.
11. Dunning T. Aromatherapy: Overview, safety, and quality issues. *OA Altern Med*. 2013; 1(1): 6.
12. Koyama S, Heinbockel T. The effects of essential oils and terpenes in relation to their routes of intake and application. *Int J Mol Sci*. 2020; 21(5): 1558.
13. Wen W, Xu P, Xiang H, et al. Comprehensive two-dimensional countercurrent chromatography × gas chromatography characterization of *Artemisia argyi* essential oil. *Anal Chim Acta*. 2023; 1237: 340614.
14. Fung TK, Lau BW, Ngai SP, Tsang HW. Therapeutic effect and mechanisms of essential oils in mood disorders: Interaction between the nervous and respiratory systems. *Int J Mol Sci*. 2021; 22(9): 4844.
15. Djilani A, Dicko A. The therapeutic benefits of essential oils. In: *Nutrition, Well-Being and Health*. 2012; (7): 155-179.
16. Sharma P, Meena TR. Aromatherapy for sports and fitness. 2015.
17. Walk D, Poliak-Tunis M. Chronic pain management: An overview of taxonomy, conditions commonly encountered, and assessment. *Med Clin North Am*. 2016; 100(1):1-16. doi: 10.1016/j.mcna.2015.09.005
18. Gladman D, Nash P, Goto H, et al. Fatigue numeric rating scale validity, discrimination and responder definition in patients with psoriatic arthritis. *RMD Open*. 2020; 6(1): e000928. doi:10.1136/rmdopen-2019-000928
19. González-Minero FJ, Bravo-Díaz L, Ayala-Gómez A. *Rosmarinus officinalis* L. (Rosemary): An ancient plant with uses in personal healthcare and cosmetics. *Cosmetics*. 2020;7(4):77. doi:10.3390/cosmetics7040077.
20. Habtemariam S. The therapeutic potential of rosemary (*Rosmarinus officinalis*) diterpenes for Alzheimer's disease. *Evid Based Complement Alternat Med*. 2016; 2016: 2680409.
21. Zaouali Y, Bouzaine T, Boussaid M. Essential oils composition in two *Rosmarinus officinalis* L. varieties and incidence for antimicrobial and antioxidant activities. *Food Chem Toxicol*. 2010; 48(11): 3144-3152. doi:10.1016/j.fct.2010.08.010.
22. Sienkiewicz M, Lysakowska M, Pastuszka M, et al. The potential of use basil and rosemary essential oils as effective antibacterial agents. *Molecules*. 2013; 18:9334-9351.

23. Ayat ES, Shojaei A, Kobarfard F, et al. Two flavones from *Salvia leriifolia*. *Iran J Pharm Res*. 2009; 8(3): 179-184.
24. Khedher MRB, Khedher SB, Chaieb I, et al. Chemical composition and biological activities of *Salvia officinalis* essential oil from Tunisia. *Excli J*. 2017; 16:160.
25. El Hadri A, del Rio MG, Sanz J, et al. Cytotoxic activity of α-humulene and transcaryophyllene from *Salvia officinalis* in animal and human tumor cells. *An R Acad Nac Farm*. 2010; 76(3): 343-356.
26. Moss L, Rouse M, Wesnes KA, Moss M. Differential effects of the aromas of *Salvia* species on memory and mood. *Hum Psychopharmacol Clin Exp*. 2010; 25(5): 388-396.
27. Gaballah A, Elnawasry H, Santos JA, Bressel E. The effect of pilates exercise with sage herbal consumption on respiratory functions for soccer players. *Am J Sports Sci Med*. 2016; 4(4): 103-108.
28. Babault N, Noureddine A, Amiez N, et al. Acute effects of *Salvia* supplementation on cognitive function in athletes during a fatiguing cycling exercise. *Front Nutr*. 2021; 9:49.
29. Omoba OS, Olagunju AI, Salawu SO, Boligon AA. HPLC-DAD phenolic profiling and in vitro antioxidant activities of three prominent Nigerian spices. *Prev Nutr Food Sci*. 2019; 24:179–186. doi:10.3746/pnf.2019.24.2.179.
30. Salehi Heravi M. *Gharabadin-e-Salehi*. Tehran: Lithography Press of the Dar al-Sultaneh; 1989. (in Persian)
31. Rhazes M. *Al-Hawi the Continence*. Tehran: Shahid Beheshti University of Medical Sciences; 2015.
32. Amrani S, Harnafi H, Bouanani NEH, et al. Hypolipidaemic activity of aqueous *Ocimum basilicum* extract in acute hyperlipidaemia in rats and its antioxidant property. *Phytother Res*. 2006; 20: 1040-1045. doi:10.1002/ptr.1961.
33. Sestili P, Ismail T, Calcabrini C, et al. The potential effects of *Ocimum basilicum* on health: A review of pharmacological and toxicological studies. *Expert Opin Drug Metab Toxicol*. 2018; 14(7): 679-692. doi:10.1080/17425255.2018.1484450.
34. Venâncio AM, Onofre ASC, Lira AF, et al. Chemical composition, acute toxicity, and antinociceptive activity of the essential oil of *Ocimum basilicum* L. *Planta Med*. 2011; 77: 825-829. doi:10.1055/s-0030-1250607.
35. Hosseinzadeh H, Ramezani M, Afarin Z. Effect of *Ocimum basilicum* aerial parts extract and fractions on morphine withdrawal syndrome in mice. *J Med Plants*. 2012; 11: 227–238.
36. Aye A, Jeon YD, Lee JH, et al. Anti-inflammatory activity of ethanol extract of basil (*Ocimum basilicum* L.) leaf and leaf callus on RAW 264.7 macrophage cells. *Orient Pharm Exp Med*. 2019; 19: 217–226. doi:10.1007/s13596-019-00372-2
37. Eftekhar N, Moghimi A, Hossein Boskabady M, et al. *Ocimum basilicum* affects tracheal responsiveness, lung inflammatory cells and oxidant–antioxidant biomarkers in sensitized rats. *Drug Chem Toxicol*. 2019;42:286–294. doi:10.1080/01480545.2018.1459672.
38. Beheshti F, Vakilian A, Navari M, et al. Effects of *Ocimum basilicum* L. extract on hippocampal oxidative stress, inflammation, and BDNF expression in amnesic aged rats. *Exp Aging Res*. 2023:1-16. doi:10.1080/0361073X.2023.2210240.
39. Mason L, Moore RA, Edwards JE, et al. Topical NSAIDs for chronic musculoskeletal pain: systematic review and meta-analysis. *BMC Musculoskelet Disord*. 2004; 5: 28. doi:10.1186/1471-2474-5-28.
40. Derry S, Conaghan P, da Silva JAP, et al. Topical NSAIDs for chronic musculoskeletal pain in adults. *Cochrane Database Syst Rev*. 2016; 4: CD007400. doi:10.1002/14651858.CD007400.pub3
41. Hiller K, Melzig M. *Lexikon der Arzneipflanzen und Drogen*. Heidelberg: Spektrum Akademischer Verlag; 1999.
42. Viola H, Wasowski C, Levi de Stein M, et al. Apigenin, a component of *Matricaria recutita* flowers, is a central benzodiazepine receptors-ligand with anxiolytic effects. *Planta Med*. 1995;61:213-216. doi:10.1055/s-2006-958058.

43. Baghalian K, Haghiry A, Naghavi MR, Mohammadi A. Effect of saline irrigation water on agronomical and phytochemical characters of chamomile (*Matricaria recutita* L.). *Sci Hortic.* 2008; 116: 437–441. doi:10.1016/j.scienta.2008.02.014.
44. Baghalian K, Abdoshah S, Khalighi-Sigaroodi F, Paknejad F. Physiological and phyto-chemical response to drought stress of German chamomile (*Matricaria recutita* L.). *Plant Physiol Biochem.* 2011; 49: 201–207. doi:10.1016/j.plaphy.2010.11.010.
45. Piccaglia R, Marotti M, Giovanelli E, et al. Antibacterial and antioxidant properties of Mediterranean aromatic plants. *Ind Crops Prod.* 1992; 2: 47-50.
46. Al-Snafi AE. Medical importance of *Anthemis nobilis (Chamaemelum nobile)*: A review. Asian J Pharm Sci Technol. 2016; 6(2): 89-95. http://hdl.handle.net/10198/6992.
47. Al-Jawad FH, et al. Broncho-relaxant activity of *Nigella sativa* versus *Anthemis nobilis* in chronic bronchial asthma: A comparative study. *IOSR J Pharm.* 2012; 2(4): 81-83.
48. Jeong JS, Kwon SJ, Cho TD. A study on the preference factor of pot aromatic herbs. *J People Plants Environ.* 2000;3:69–83.
49. Shin YS, Cho YS, Jung YJ. The effects of aromatherapy on autonomic nerve system and physical resistance of a stress. *J Korean Biol Nurs Sci.* 2004;6:5–17.
50. Langer SZ. Presynaptic regulation of the release of catecholamines. *Pharmacol Rev.* 1980; 32:337–362.
51. Tianlong D, Sim YJ. Effects of different recovery methods on post-boxing sparring fatigue substances and stress hormones. *J Exerc Rehabil.* 2019; 15(2): 258-263. doi:10.12965/jer.1938050.025.
52. Kwon S, Ahn J, Jeon H. Can aromatherapy make people feel better throughout exercise? *Int J Environ Res Public Health.* 2020; 17(12): 4559. doi:10.3390/ijerph17124559.
53. Peluso MAM, Andrade LHSGD. Physical activity and mental health: the association between exercise and mood. *Clinics.* 2005; 60: 61–70.



Graphical Abstract