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Research Article

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Impact of the COVID-19 Pandemic on Surgical Residency Training: Time to Digitalization

Wael Gazzah[1*], Mayssa Khribi[2], Khalil Gnaba[2], Badreddine Ben Khalifa[1], Sahbi Naouar[1] and Salem Braiek[1]

[1]*University of Sousse, Faculty of Medicine, Department of Urology, Ibn El Jazzar Hospital, Kairouan, Tunisia*

[2]*University of Sousse, Faculty of Medicine, Department of ENT, Ibn El Jazzar Hospital, Kairouan, Tunisia*

[*]Corresponding Author
Wael Gazzah, Department of Urology, Ibn El Jazzar Hospital, Kairouan, Tunisia.

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Abstract

Background: *The COVID-19 pandemic has had a profound impact on medical education, particularly in surgical specialties. Surgical training, traditionally reliant on hands-on experience, has faced unprecedented challenges due to reduced clinical activities and elective surgeries.*

Aim: *The primary aim of this study was to evaluate the effects of the COVID-19 pandemic on the clinical and surgical training of Tunisian surgical residents, along with their psychological well-being. Additionally, the study aimed to propose feasible and cost-effective measures for enhancing surgical training in low-income countries, like Tunisia, during and after the pandemic.*

Methods: *A cross-sectional survey was conducted at a teaching hospital in Tunisia between December 1st and 30th, 2020. The survey, distributed to 36 surgical residents, included questions on demographic characteristics, training activities, and psychological impact using the GAD-7 and PHQ-9 questionnaires. Data on respondents' suggestions for training improvements were also collected.*

Results: *Of the invited residents, 72% (26 participants) responded. The respondents reported a significant reduction in clinical and surgical training opportunities, with 85% believing the pandemic negatively impacted their training. Psychological assessment revealed increased stress and anxiety among all participants, with 77% showing signs of depression. The residents suggested increasing the frequency of teleconference-based college courses and clinical case discussion sessions. Additionally, the adoption of low-cost simulation-based training, free access to online surgical video libraries, and use of the Touch Surgery application were highlighted as valuable tools.*

Conclusion: *The COVID-19 pandemic has significantly disrupted surgical residency training in Tunisia, impacting both the training quality and psychological well-being of residents. The findings emphasize the need for innovative training methodologies in low-resource settings. Proposed measures, including simulation-based training using low-cost models and enhanced digital resources, offer practical solutions to sustain surgical education during such global crises. The study underscores the importance of adapting and expanding surgical training methodologies to ensure continued learning and skill development in challenging times.*

Keywords: Pandemic, Surgical Residency Training, Medical Education, Digitalization, Surgery, Simulation Training, Telemedicine

Abbreviations

COVID-19: Coronavirus disease 2019
WHO: World Health Organization
GAD: General Anxiety Disorder
PHQ: Patient Health Questionnaire
TS: Touch surgery
VR: Virtual Reality
AR: Augmented Reality

1. Introduction

The rigorous nature of surgical residency training, historically characterized by intensive hands-on experience and patient interaction, faced an unprecedented disruption with the onset of the coronavirus disease 2019 (COVID-19) pandemic. Declared a global health emergency in March 2020 by the World Health Organization (WHO), the pandemic necessitated a rapid and significant alteration in postgraduate medical training methodologies, especially in surgical specialties [1]. This abrupt transition, stemming from the necessity to curtail clinical and surgical activities, profoundly affected the traditional training model, heavily reliant on patient flow and direct surgical involvement.

Compounding the situation, the decrease in practical training opportunities has had a ripple effect on the psychological well-being of surgical residents. Studies have indicated a correlation between reduced clinical exposure and increased stress and anxiety among trainees [2]. This study aims to provide a comprehensive evaluation of these impacts within a Tunisian cohort of surgical residents. Through a cross-sectional survey, we assess the extent to which the COVID-19 pandemic has altered the trajectory of surgical residency training and its consequent effect on the psychological health of residents.

Furthermore, recognizing the necessity for adaptive training methodologies in times of reduced physical patient interaction, this study also explores the potential of digital simulation-based training. By reviewing various tools and techniques reported in the literature, we aim to underscore the importance of innovative and flexible training approaches in maintaining the continuum of surgical education during unprecedented crises such as a pandemic.

2. Material and Methods

2.1. Survey Procedure

This cross-sectional survey was conducted in the surgical division of our teaching hospital, encompassing specialties like general surgery, urology, Ear-nose-throat (ENT), ophthalmology, orthopedic surgery, and gynecology-obstetrics. The survey timeframe spanned from December 1st to 30th, 2020.

A study-specific electronic questionnaire was designed using Google Forms®. It comprised 8 items developed based on a comprehensive literature review of the impacts of pandemics on medical training and psychological well-being. These items were structured to gauge the impact of the pandemic on both training and psychological well-being of surgical residents. Our sample included residents at various stages of their training, providing a broad perspective on the training experience.

To ensure broad and inclusive participation, the questionnaire was distributed among 36 surgical residents, reaching 31 participants through email and 5 via WhatsApp. This dual-mode distribution was adopted to enhance accessibility and response rate. Participation was voluntary, and the objectives of the survey were clearly communicated to all potential participants. Informed consent was implied by the act of survey submission, with respondents clicking an 'agree' button before participating. Responses were anonymized to maintain confidentiality.

Reminders were sent to non-respondents two weeks following the initial invitation. The collected data were then analyzed using Google Forms®, with attention to descriptive statistics to summarize the data, including means and standard deviations. The study protocol received approval from the ethics and research unit of Ibn El Jazzar teaching hospital in Kairouan, Tunisia, ensuring adherence to ethical research standards.

2.2. Questionnaire

The questionnaire was thoughtfully designed to capture a range of data relevant to the study's goals. It began by collecting demographic information such as age, gender, residency year, and surgical specialty to establish the background of the respondents. This was followed by questions assessing the impact of the pandemic on various aspects of the academic program, including changes to lectures, workshops, and the handling of elective surgeries. We also explored the adjustments in clinical and surgical training experiences, focusing on how these aspects were affected and adapted during the pandemic.

Another key area of the questionnaire addressed the mode of training activities, particularly examining the shift towards virtual learning or simulation-based approaches. We also sought to understand the perceived impact of the pandemic on residents' career progression, gathering insights into their concerns and expectations.

Crucially, the questionnaire included sections using the Generalized Anxiety Disorder (GAD-7) and Patient Health Questionnaire (PHQ-9) scales to assess the psychological effects of the pandemic on the surgical residents. These scales are widely recognized for their effectiveness in measuring anxiety and depression symptoms and were chosen for their proven reliability in clinical settings. Additionally, we included questions aimed at identifying the residents' needs for training improvement, pinpointing specific areas where additional support or resources might be necessary.

The questionnaire predominantly comprised multiple-choice questions to facilitate straightforward analysis, alongside a few open-ended questions for more nuanced responses. These open-ended items, such as inquiries about the number of cases managed during the pandemic, provided valuable qualitative data.

3. Results

3.1. Subject Characteristics

Out of 36 residents invited, 26 (72%) completed and submitted the questionnaire by the end of the study period. The average age of respondents was 27.9 ± 2.07 years, ranging from 25 to 34 years. When broken down by specialty, urology and ENT residents were most represented, though specific numbers or percentages for each specialty are detailed in Table 1. Notably, half of the respondents reported having contracted COVID-19 during their training, yet all had completed their vaccination regimen, as shown in Table 1.

Characteristics	Number	Percentage (%)
Age *(years)*		
25-29	22	84.6
30-35	4	15.4
Specialty *(respondents/total)*		
General surgery	3/6	11.5
Urology	6/6	23.1
Orthopaedic surgery	4/6	15.4
Ear, nose and throat surgery	6/6	23.1
Ophthalmology	3/4	11.5
Gynaecology	4/8	15.4
Total	26/36	
Residency year		
First	12	46.2
Second	7	26.9
Third	3	11.5
Fourth	3	11.5
Fifth	1	3.8
Covid-19 vaccination	26	100
Covid-19 infestation	13	50

Table 1: Socio-Demographic Characteristics of Respondents

3.2. Impact of the Pandemic on Clinical and Surgical Training

The pandemic's influence on residency training was predominantly perceived as negative, with 85% of respondents believing it adversely affected their training. This concern extended to their career progression, with 69% expressing anxiety about potential delays or hindrances, as illustrated in Table 2.

In the outpatient setting, a significant decline in patient interaction was observed, with 96% of respondents seeing fewer patients since the pandemic's onset. Detailed in Table 2, 88.5% (23 respondents) reported a substantial reduction in elective surgeries, translating to less than one procedure per week for 34.6% of them. Notably, 27% (seven respondents) experienced a complete cessation of elective surgical activities.

Characteristics	Number	Percentage (%)
Outpatient consultations		
Moderate decrease	4	15.3
Major decrease	9	34.6
Complete interruption	11	42.3
No change	1	3.8
Elective surgeries attendance		
Decrease with one or more intervention per week	7	26.9
Decrease with less than one intervention per week	9	34.6
Complete interruption	7	26.9
No change	3	11.5
Emergency surgeries attendance		
Decrease	23	88.6
Increase	3	11.5
No change	0	
Research activity *(article writing...)*		
Decrease	10	38.4
Increase	3	11.5
No activity	11	42.3
No change	2	7.7

Table 2: Impact of Covid-19 on Clinical Experience and Activities

3.3. Sources of Training During the Pandemic

Throughout the pandemic, clinical training adapted to the restrictions, relying primarily on patient bedside learning during daily medical visits, as reported by half of the respondents. Additionally, 38.4% of the trainees engaged in college courses conducted via teleconferencing platforms. Notably, nearly a quarter of respondents (27%) participated in clinical case discussion sessions through digital platforms such as Zoom® and Google Meet®, as detailed in Table 3.

The landscape of surgical training witnessed a shift towards digital and theoretical resources. A significant proportion of residents (65.4%) utilized the medico-surgical encyclopedia as a primary source of information. Concurrently, 61.5% turned to online platforms like YouTube® for surgical videos, supplementing their reduced exposure to practical experiences.

More than half of the participants (53.8%) had the opportunity to attend emergent surgeries. However, only 42% (11 respondents) reported the continuation of a didactic teaching program by their specialty's college, which consisted of theoretical courses and clinical case discussions conducted via teleconferences, as shown in Table 3.

Training source	Number	Percentage (%)
Clinical training		
Patient "bedside" learning	13	50
Periodic medical staff	8	30.7
Clinical cases discussion sessions via webinar	7	27
College's course via webinar	10	38.4
Surgical training		
Surgical videos on YouTube®	16	61.5
Surgical video libraries	4	15.3
Medico-surgical encyclopedia	17	65.3
Online Atlas with 3D-images	4	15.3
Pre-recorded videos	7	26.9
Attendance of emergent surgeries	14	53.8
Simulation program	0	0
Touch surgery	0	0
Residents suggestions		
Clinical training		
Theoretical courses Plateform with clear goals	14	53.8
College's courses via teleconferences	17	65.3
Clinical cases discussion sessions via teleconferences	15	57.7
Clinical vignette-based interactive discussion sessions via teleconferences or social media	15	57.7
Surgical training		
Portfolio	3	11.5
Free access to surgical videos libraries	15	57.7
Virtual simulation	24	92.3
Plateform for prerecorded surgical videos	12	46
Prolonging training for at least 6 months	7	27

Table 3: Sources of Training During Pandemic and Residents Suggestions

3.4. Impact of the Pandemic on Psychological Well-being

The pandemic's toll on the mental health of surgical residents was quantitatively assessed using the GAD-7 and PHQ-9 scales. The GAD-7 scale, a tool for screening and measuring the severity of generalized anxiety disorder, revealed increased stress and anxiety levels among all participants. Specifically, anxiety was classified as mild in 80.7% and moderate in 19.3% of respondents based on their score ranges.

Similarly, the PHQ-9 scale, used to screen and measure the severity of depression, indicated that a significant proportion of residents were experiencing depressive symptoms. In detail, 50% of respondents showed mild depression, 15.4% moderate, and 11.5% severe, amounting to 77% of the participants presenting some level of depression.

These findings underscore the considerable psychological impact the pandemic has had on surgical residents. The high prevalence of anxiety and depression raises concerns about their well-being and potential implications for their training and professional development.

3.5. Residents' Suggestions to Improve Training

The residents provided insightful suggestions for enhancing both clinical and surgical training in the context of ongoing pandemic restrictions.

A significant portion of respondents (65.4%) advocated for an increased frequency of college courses delivered via teleconference, suggesting more regular scheduling and diversification of topics. Additionally, 57.7% of residents expressed a desire for more clinical case discussion sessions, emphasizing the need for interactive, case-based learning to supplement hands-on experiences. Similarly, there was interest (57.7%) in incorporating clinical vignette-based interactive discussions, utilizing teleconferencing platforms or social media for more engaging and accessible learning opportunities.

An overwhelming majority (92%) proposed periodic training sessions using surgical simulators. These sessions are envisioned to provide practical experience in a controlled environment, compensating for the decreased opportunities in operating rooms. Furthermore, 57.7% of participants suggested providing free access to online surgical video libraries, emphasizing the value of visual learning tools in surgical education and the potential for self-guided learning outside the traditional clinical setting, as detailed in Table 3.

4. Discussion

Our study underscores the significant disruption caused by the COVID-19 pandemic on the clinical and surgical training of residents, manifesting in heightened levels of anxiety (100%) and depression (77%). The dramatic reduction in patient

interactions during outpatient consultations (96%) and elective surgeries (88.5%) underscores a critical challenge in maintaining the quality of surgical education during the pandemic.

This diminution of practical training opportunities resonates with findings from other studies across different regions and specialties [3-5]. For instance, a survey in the UK and Republic of Ireland, with 810 respondents, revealed that only 9% of surgical trainees felt confident about meeting all required competencies during the pandemic [6]. The suspension of elective non-oncologic surgeries and endoscopy, as noted in our study, has been a common theme, significantly curtailing hands-on training experiences.

Notably, our study highlights a gap in addressing the psychomotor aspects of surgical training during this period. While 42% of respondents reported some adaptation in didactic teaching methods, such as the implementation of teleconference-based theoretical courses and case discussions, there was an apparent lack of initiative from surgical colleges to innovate or supplement psychomotor skill training. This oversight warrants attention, as the development of these skills is integral to surgical proficiency.

The limitations of our study, including its single-center design and the relatively small sample size, may affect the generalizability of these findings. However, they do mirror broader trends observed in surgical education during the pandemic.

Given these findings, there is a clear need for future research to explore effective strategies for integrating psychomotor training into surgical education, especially in times of crisis. Additionally, our study suggests the necessity for policy changes and the adoption of more flexible, resilient training models that can withstand similar disruptions.

During the pandemic, teleconferences and webinars rapidly evolved as vital tools for continuing clinical education. Notably, reciprocal teaching conferences, facilitating interaction between different institutions, emerged as effective platforms for knowledge exchange and collaborative learning.

Virtual meeting tools such as Zoom®, Google Meet®, and GoToMeeting® played a crucial role in implementing didactic clinical education sessions. These sessions encompassed a range of activities, including case discussions, updates on guidelines, and lectures on new articles [7]. The shift to virtual platforms also fostered innovative approaches to exam preparation and surgical discussions, as demonstrated by Chick et al., who utilized a closed Facebook group for daily practice questions and topic discussions, thus eliminating the need for in-person gatherings [8].

A particularly effective approach was the flipped virtual classroom. In this model, didactic materials in the form of prerecorded videos were provided to learners, allowing them to engage with the content at their convenience before scheduled conferences focused on synthesis, application, and case-based discussions [7, 9]. This method proved beneficial in offering flexibility and promoting active learning, aligning well with trainee preferences for more interactive and autonomous educational experiences, as reported in our study and supported by other literature [10].

This shift in pedagogic techniques not only ensured the continuity of education during challenging times but also highlighted the potential for long-term adaptations in medical training methodologies.

Surgical training has traditionally been rooted in an apprenticeship model, where trainees learn directly under the guidance of experienced surgeons [11]. However, with the advent of laparoscopy and minimally invasive surgery, the field has seen a shift towards incorporating simulation-based training techniques. Ranging from basic table-top box trainers to advanced simulators that combine digital tools, these methods have been increasingly integrated into academic surgical curricula. Literature highlights that simulation-based training not only complements but, in some aspects, surpasses traditional training models in enhancing surgical performance [12-14].

In recent years, medical simulation has seen significant growth. An exemplary tool is Touch Surgery (TS), a free interactive surgery simulator application for iOS®. TS utilizes a touchscreen interface and three-dimensional (3D) graphics to create a realistic surgical environment. It allows users to navigate various surgical procedures across multiple specialties. The program's structure includes a "tutorial" module for teaching operative steps, followed by a "test" module to assess users' understanding of the procedure's components and techniques. Studies, including those by Tulip et al., have reported high satisfaction rates among trainees using TS [15]. Additionally, its effectiveness in improving cognitive surgical skills has been validated, suggesting that it enables trainees to concentrate more effectively on developing psychomotor skills [15, 16]. However, the direct transferability of these skills to operating room efficiency remains an area for further investigation.

Recently, the surgical training landscape has witnessed a paradigm shift with the advent of advanced digital technologies such as Virtual Reality (VR) and Augmented Reality (AR). VR, which can be either partial or fully immersive, requires a combination of a computer for interactive 3D visualization, a head-mounted display, and controllers equipped with position trackers. This setup, particularly in full immersion, offers a highly realistic environment enhanced by haptic feedback from handheld controllers, providing tactile sensations that mimic real-life surgical procedures [17].

AR takes this a step further by overlaying the virtual environment onto a 3D real-world setting, offering a “live view” that combines virtual elements with the actual physical environment. This technology is especially promising in tailoring training to specific patient scenarios, allowing for a more personalized and contextually relevant learning experience [18].

These digital tools represent a significant leap from the traditional apprenticeship model, offering immersive, interactive experiences that can better prepare surgeons for the complexities

of modern procedures. Their integration into surgical training programs poses both opportunities for enhanced learning and challenges, particularly in terms of accessibility and the need for specialized equipment.

While the potential of VR and AR in surgical training is vast, evidenced by studies highlighting their effectiveness in improving surgical skills, there remain areas necessitating further research. These include the direct transferability of skills acquired via VR and AR to the operating room and the long-term impact on surgical proficiency and patient outcomes.

VR/AR simulation has emerged as a flexible and powerful tool in surgical training, enabling trainees to learn basic skills in a secure, controlled environment with regular feedback. This technology allows for the design of targeted training programs with specific goals, providing novice trainees with valuable preparatory experience before they engage in real-life operating theatre scenarios.

Various specialties have increasingly incorporated VR simulation into their residency training programs. Notable examples include orthopedic surgery, using platforms like TraumaVison® and OssoVR®, neurosurgery with Immersive Touch®, laparoscopy training via LAP Mentor®, and applications in plastic surgery and endoscopy. A Cochrane systematic review has underscored the advantages of VR simulation training, demonstrating its superiority over traditional methods and its ability to supplement conventional endoscopy training [19]. Moreover, VR simulation has been shown to reduce real-life error rates, enhancing skill acquisition and patient safety [20].

For effective integration of digital simulation training, programs must be designed with clear objectives and provide prompt instructions. Supervision, assessment of surgical skills through appropriate scoring systems, and constructive feedback are crucial components for achieving targeted competencies.

However, a significant challenge in adopting these digital technologies, particularly in resource-limited countries like Tunisia, is the difficulty and cost associated with creating high-fidelity virtual environments. The literature evaluating simulation-based training in low-income settings remains sparse, and in our context, the use of such simulators for surgical training is notably limited due to logistical and financial constraints [14].

Future research should focus on developing cost-effective and logistically feasible VR/AR simulation solutions for low-resource settings. Exploring innovative approaches and alternative technologies that can provide similar training benefits at a lower cost could be a valuable direction, ensuring that the advancements in surgical education are accessible and beneficial to a broader range of training environments worldwide.

Intriguingly, some initiatives have demonstrated that academic collaboration between African countries and international institutions can facilitate the implementation of effective, low-cost simulation-based training programs. A notable example of this is the partnership between Tenwek Hospital in Kenya and the University of Kentucky in the USA. This collaboration enabled the introduction of a laparoscopic skills curriculum, initially created and validated in the USA, to Tenwek Hospital's general surgery residents.

The curriculum was adapted to local needs and resources, with simulation materials and the entire program costing merely 50 USD per participant. This cost-effectiveness greatly enhanced the accessibility and feasibility of the program. The curriculum covered key aspects of laparoscopic surgery, tailored to the proficiency levels of the residents and the specific requirements of their training environment.

The performance of residents was rigorously assessed throughout the curriculum, using established metrics to track their progress and skill development. By the program's conclusion, there was a significant improvement in the residents' laparoscopic skills, as evidenced by these assessments [21].

This model serves as a compelling example for other resource-limited settings, demonstrating that strategic collaborations and innovative adaptations can yield substantial improvements in surgical training quality, even with limited financial resources. The success of this program suggests a viable pathway for similar institutions seeking to enhance surgical training through cost-effective simulation models.

To enhance the quality of surgical training during residency in countries with low income, we propose the following measures:

Firstly, medical universities should actively promote and facilitate simulation-based training. This can be achieved by providing low-cost trainer boxes and developing structured simulation programs. Each program should have a designated mentor in its respective specialty, clearly defined goals, and a robust system for assessment and feedback. These programs ought to be seamlessly integrated into the academic surgical curriculum. Moreover, fostering collaborations between institutions in low-income countries and international entities could facilitate access to low-cost trainers and international simulation-training programs, thereby enhancing the quality and diversity of training options available.

Secondly, there should be an initiative by medical universities to facilitate easier access to online surgical video libraries. This could involve negotiating with platform providers for institutional access or curating a repository of high-quality surgical videos for student and faculty use.

Thirdly, we advocate for the practice of self-reviewing prerecorded surgical videos, such as laparoscopy and endoscopy procedures. This should be complemented by regular discussions with mentors during medical staff meetings to analyze learning points and reinforce practical knowledge.

Finally, we recommend the use of the Touch Surgery (TS) application for residents, particularly those in the early stages of their training. This app, freely available on the Apple Store and Google Play Store, provides a platform for residents to

familiarize themselves with various surgical procedures before actual practice in the operating theatre. The interactive, step-by-step guidance offered by TS can be an invaluable tool in preparing novice trainees for real-life surgical experiences.

4.1. Advantages of the Study

This study represents the first comprehensive evaluation of the impact of the COVID-19 pandemic on surgical residency training in Tunisia. It offers unique insights into the challenges faced by residents during this unprecedented period and provides actionable measures tailored to the context of resource-limited countries. The proposed measures not only address the immediate concerns brought forth by the pandemic but also lay the groundwork for long-term improvements in surgical training in settings similar to Tunisia.

4.2. Limitations of the Study

Despite its contributions, this study has certain limitations. Being monocentric, it reflects the experiences of a single institution, which may not fully represent the diverse training environments across Tunisia. Additionally, the sample size was relatively small, and the majority of respondents were in the first two years of their training. This concentration of early-stage residents could potentially skew the perception of the pandemic's impact, as their experiences and training needs might differ significantly from those in later stages of residency.

These limitations highlight the need for future research involving a broader range of institutions and a more diverse sample of residents, encompassing various stages of training. Such studies could provide a more holistic understanding of the pandemic's impact on surgical training and further validate or refine the measures proposed in this research.

5. Conclusion

The COVID-19 pandemic has underscored a critical need for adaptability and innovation in surgical training during residency. Our study reveals that simulation-based training has emerged as a crucial complement to traditional methods, particularly when access to operating theatres is limited. Digital simulation presents a promising avenue for enhancing psychomotor skills, though its widespread adoption is hampered by high costs.

In response to these challenges, especially in low-income countries like Tunisia, our study advocates for the utilization of low-cost trainer boxes, free access to online surgical video libraries, and the use of prerecorded surgical videos for didactic learning. These cost-effective tools can play a pivotal role in enhancing surgical training, ensuring that residents continue to receive comprehensive education even in resource-constrained settings.

This study not only provides insights for Tunisia but also for other countries facing similar challenges. It highlights the necessity for surgical education systems worldwide to evolve, integrating innovative, accessible training methods that can withstand disruptions like a global pandemic. As we move forward, the focus must be on developing sustainable, adaptable, and inclusive training models that ensure the highest standards of surgical education and patient care, regardless of geographical or economic barriers.

Informed Consent and Patient Details: In this study, informed consent was implied by survey submission, following clear communication of study objectives to voluntary participants, and all responses were anonymized to ensure participant confidentiality, with approval from the ethics and research unit of Ibn El Jazzar teaching hospital in Kairouan, Tunisia.

Declaration of Interest: The authors declare no conflicts of interest relevant to this article.

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