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REVIEW

Robotic-assisted surgery in the Arab world: are we there yet?

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Abstract
Robotic-assisted surgery (RAS) has revolutionized surgical practice worldwide, with urology leading its adoption. Despite its global expansion, significant disparities exist in regional implementation, particularly in the Arab world. This study evaluates the current landscape of robotic surgery in the Arab world, highlighting advancements, challenges, and future directions. A literature review was conducted using PubMed, focusing on robotic procedures across multiple specialties in Arab countries. Data on installed robotic systems were obtained from industry reports and local distributors. A total of 56 relevant publications were identified. The highest volume of RAS publications originated from Saudi Arabia, Qatar, and the United Arab Emirates. Emerging trends include a rise in multidisciplinary robotic procedures, innovative telesurgical applications, and increased research output. However, high-quality, large-scale studies remain limited. The Arab world has made notable strides in RAS adoption, with key centers advancing research and clinical practice. Although full integration remains a work in progress, the foundation for widespread robotic surgical adoption in the Arab world is firmly in place.

Keywords Robotic surgery · Arab world · Surgical innovation · Telesurgery · Surgical equity · Global surgery

Introduction

Robotic-assisted surgery (RAS) has redefined the standards of care in multiple surgical fields, with urology spearheading its adoption. It has been proven to be the superior surgical technique when looking at perioperative clinical parameters and even long-term functional outcomes in some indications such as radical prostatectomy [1]. The worldwide adoption of robotic surgery has increased exponentially with a paradigm shift in practice [2]. The introduction of 3D vision, more freedom of movement with EndoWrist® (Intuitive Surgical Inc., Sunnyvale, CA, USA) technology, and minimized tremor have made it the primary choice for technically challenging cases within the general surgery, urology, gynecology, head and neck and cardiothoracic realms [3]. Despite global success, disparities exist in regional implementation [2, 4, 5]. The Arab world is emerging as a key player in RAS, fueled by investments in technology and growing expertise. However, the global population distribution does not correlate with the availability of robotic surgery in the region, which creates healthcare inequity (Fig. 1). Looking at the population of the Arab world compared to Europe and North America, it amounts to 1/3 of the distribution. However, the approximate distribution of robotic consoles is less than 1% of the global distribution [6]. This paper reviews advancements since earlier evaluations [7, 8], addressing evolving trends and challenges unique to the region.

Methods

A comprehensive review of the robotic surgery landscape in the Arab world was conducted using a multi-faceted approach. A PubMed search was performed on December 8, 2024 using the keywords' robot-assisted surgery,'

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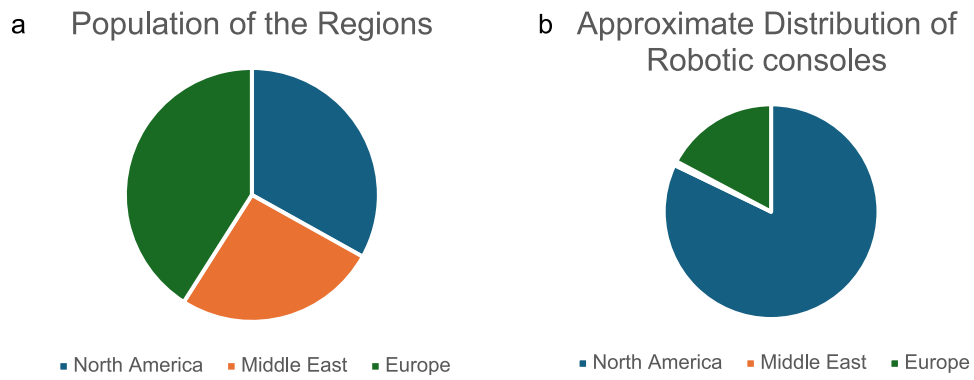

Fig. 1 **a** Approximate Global Population distribution among the three regions; North America, Middle East and Europe **b** Approximate Global Distribution of robotic consoles among those regions

combined with specific procedures, such as radical prostatectomy, partial nephrectomy, bariatric surgery, and robotic hysterectomy. The search criteria were expanded to include country-specific keywords, such as Saudi Arabia, Egypt, Lebanon, United Arab Emirates, Kuwait, Qatar, Tunisia, Bahrain, and Oman. Full-text articles in English relevant to the scope of this review were selected, prioritizing landmark studies and those that highlighted trends and future directions for robot-assisted surgery. Decisions on inclusion of the study in this review were made by three fellowship-trained urologists in robotic surgery. Additionally, data on the number of installed Da Vinci Surgical Systems globally were sourced from the Intuitive Surgical's official quarterly presentations and annual reports. Further insights, including region-specific figures, were obtained from operational records shared by local distributors of the Da Vinci Surgical Systems across the Arab world. This method ensures a thorough and reliable understanding of the regional adoption and application of robotic surgery.

Results

Overall, 56 publications that were deemed suitable for inclusion in this review of robotic surgery in the Arab world were retrieved from our literature search. The publications were released over a span of 17 years (2007–2024). However, 39 of those publications were published between 2020 and 2024. Most of the studies consisted of surgical videos, case reports, and case series. Other studies included initial experiences of tertiary centers, single-center experiences, multicenter studies, and perspectives on the development of robotic surgery in the Arab world (Table 1). The top three countries that produced publications were Saudi Arabia, Qatar, and the United Arab Emirates. A summary of these studies is presented in Table 1. Our data curation from local vendors regarding the availability of robotic consoles in the Arab region is shown in Fig. 2. A breakdown of the different numbers and types of procedures performed in each country is included in the supplementary material.

Discussion

Historical background and current trends

The adoption of robotic surgical systems in the Arab world began in the early 2000s, marking a significant shift in the region's approach to advanced surgical techniques. The first robotic surgical procedure in this region was performed in 2003 in Saudi Arabia using the Da Vinci Surgical System [8]. This milestone positioned Saudi Arabia as a pioneer in robot-assisted surgery in the Arab world. Over subsequent years, other countries in the region, including the UAE, Qatar, and Lebanon, followed suit and introduced robotic systems in leading medical centers. Early cases focused primarily on urological and gynecological procedures [9, 10], reflecting the global trends in the initial adoption of robotic surgery.

In recent years, the volume of robot-assisted surgeries has increased significantly, driven by rising demand, technological advancements, and expanding expertise in the field. Centers in Saudi Arabia, Qatar, the United Arab Emirates, and Lebanon have become regional leaders, performing high volumes of robotic procedures annually as well as increasing the diversity of cases, widening the scope of practice to include other disciplines, such as general surgery and gynecology, as evident from the publications. This becomes a self-propagating cycle, as Grimsley et al. mention in their article [11]. The trend toward higher case volumes reflects both the growing acceptance of robotic surgery as a standard of care and the continuous investment in training and technology to enhance surgical outcomes in the Arab world. One key finding of our review is the significant number of publications that describe the general public and provider perspectives on robotic surgery. This reflects the keen interest in adopting RAS as well as the identification of the lack of adoption in the region despite the infrastructure and perspective being ripe for implementation. One key element is public awareness about RAS, and studies have

Table 1 List of publications associated with Robotic Surgery from the Arab Region

Author	Publication year	Article type	Topic of article	Specialty	Country of origin	DOI
Abou Heidar et al	2023	Original Article	Robotic Radical Prostatectomy	Urology	Lebanon	https://doi.org/10.1177/17562872231177780
Al Dhaheri et al	2023	Surgical Video	Robotic Colectomy	General Surgery	Qatar	https://doi.org/10.1111/codi.16703
Al Dihan	2024	Survey	Robotic Surgery Adoption	N/A	Saudi Arabia	https://doi.org/10.7759/cureus.56523
Al-Badawi	2010	Case Report	Robotic Salpingostomy	Gynecology	Saudi Arabia	https://doi.org/10.1016/s1701-2163(16)34562-5
Al-Badawi et al	2012	Case Report	Robotic Oophorectomy	Gynecology	Saudi Arabia	https://doi.org/10.1007/s11701-011-0274-7
Al-Dousari et al	2021	Original Article	Robotic Radical Prostatectomy	Urology	Kuwait	https://doi.org/10.1007/s11701-020-01089-0
Al-Dousari et al	2021	Survey	Robotic Surgery Adoption	N/A	Kuwait	https://doi.org/10.1007/s11701-020-01136-w
Al-Dousari et al	2021	Original Article	Robotic Partial Nephrectomy	Urology	Kuwait	https://doi.org/10.5489/cuaj.6880
Alkhamis et al	2024	Original Article	Robotic Colorectal	General Surgery	Kuwait	https://doi.org/10.1159/000538635
Alkhamis et al	2024	Original Article	Robotic Colorectal	General Surgery	Kuwait	https://doi.org/10.1097/DCR.0000000000003346
Al-Naami	2013	Original Article	Robotic Abdominal Surgery	General Surgery	Saudi Arabia	https://doi.org/10.1002/rcs.1521
Al-Othman et al	2014	Case Report	Robotic Partial Cystectomy	Urology	Saudi Arabia	https://doi.org/10.1590/S1677-5538.IBJU.2014.01.20
Al-Thani h et al	2022	Original Article	Robotic Adrenalectomy	General Surgery	Qatar	https://doi.org/10.3389/fsurg.2022.848565
Al-Thani h et al	2017	Original Article	Robotic Gastrectomy	General Surgery	Qatar	https://doi.org/10.1002/rcs.1729
Al-Yousef et al	2017	Case Report	Robotic Pyelolithotomy	Urology	Saudi Arabia	https://doi.org/10.1590/S1677-5538.IBJU.2016.0059
Alkhatry et al	2024	Surgical Video	Robotic Hiatal Hernia Repair and Cruroplasty	General Surgery	United Arab Emirates	https://doi.org/10.1055/a-2387-3881
Alyami et al	2024	Original Article	Robotic Abdominal Surgery	General Surgery	Saudi Arabia	https://doi.org/10.1002/jso.27902
Amir-Khalili et al	2014	Original Article	Robotic Technology	Urology	Qatar	https://doi.org/10.1007/978-3-319-10.404-1_51
Arafah et al	2021	Case Report	Robotic Hysterectomy	Gynecology	Saudi Arabia	https://doi.org/10.12659/AJCR.932916
Ayoub et al	2023	Original Article	Robotic Technology	N/A	Lebanon	https://doi.org/10.1007/s00345-023-04573-y

Table 1 (continued)

Author	Publication year	Article type	Topic of article	Specialty	Country of origin	DOI
Azevedo et al	2023	Multicenter Study	Robotic Colectomy	General Surgery	Qatar	https://doi.org/10.1007/s00423-023-03043-8
Azhar et al	2021	Multicenter Study	Robotic Radical Prostatectomy	Urology	Saudi Arabia, Kuwait	https://doi.org/10.1089/end.2020.0770
Azhar et al	2018	Survey	Robotic Surgery Adoption	Urology	Saudi Arabia	https://doi.org/10.4103/UA.UA_8_18
Azhar et al	2022	Consensus Guidelines	Robotic Surgery Adoption	Urology	Saudi Arabia	https://doi.org/10.4103/ua.ua_46_22
Azhar et al	2024	Original Article	Robotic Adrenalectomy	Urology	Saudi Arabia	https://doi.org/10.7759/cureus.55276
Barkati et al	2021	Survey	Robotic Surgery Adoption	N/A	United Arab Emirates	https://doi.org/10.1007/s11701-023-01716-6
Buabbas et al	2020	Survey	Robotic Surgery Adoption	N/A	Kuwait	https://doi.org/10.1186/s12911-020-01167-1
Debakey et al	2018	Case Report	Robotic Colectomy	General Surgery	Egypt	https://doi.org/10.7759/cureus.32005
El-Asmar et al	2021	Original Article	Robotic Partial Nephrectomy	Urology	Lebanon	https://doi.org/10.7759/cureus.16461
El Dahdah et al	2023	Original Article	Robotic Abdominal Surgery	General Surgery	United Arab Emirates	https://doi.org/10.1007/s11701-022-01471-0
Elmoghazy et al	2023	Original Article	Robotic Liver Cystectomy	General Surgery	Egypt	https://doi.org/10.1007/s00423-023-03043-8
Halabi et al	2022	Original Article	Robotic Cholecystectomy, Robotic Herniorrhaphy	General Surgery	United Arab Emirates	https://doi.org/10.1007/s11701-022-01407-8
Halabi et al	2024	Original Article	Robotic Cholecystectomy, Robotic Herniorrhaphy	General Surgery	United Arab Emirates	https://doi.org/10.1007/s11701-023-01806-5
Halabi et al	2023	Case Report	Robotic Herniorrhaphy	General Surgery	United Arab Emirates	https://doi.org/10.1016/j.ijscr.2023.108123
Haroon et al	2024	Case Report	Robotic Partial Nephrectomy	Urology	Qatar	https://doi.org/10.1016/j.radcr.2024.05.072
Junejo et al	2020	Original Article	Robotic Pyeloplasty	Urology	Saudi Arabia	https://doi.org/10.4103/UA.UA_113_19
Labban et al	2020	Original Article	Robotic Radical Prostatectomy	Urology	Lebanon	https://doi.org/10.1080/2090598X.2020.1814184
Latif et al	2021	Surgical Video	Robotic Colectomy	General Surgery	Qatar	https://doi.org/10.1111/codi.15650
Mahgoub et al	2023	Surgical Video	Robotic Colectomy	General Surgery	Qatar	https://doi.org/10.1111/codi.16452

Table 1 (continued)

Author	Publication year	Article type	Topic of article	Specialty	Country of origin	DOI
Muharrem oner	2024	Original Article	Robotic Cholecystectomy, Robotic Herniorrhaphy	General Surgery	United Arab Emirates	https://doi.org/10.1007/s11701-024-01936-4
Nosrati et al	2016	Original Article	Robotic Technology	N/A	Qatar	https://doi.org/10.1109/TMI.2015.2452907
Panteleimonitis et al	2023	Multicenter Study	Robotic Anastomosis	General Surgery	Qatar	https://doi.org/10.1007/s00423-023-02898-1
Rabah et al	2012	Review	Robotic Surgery Adoption	N/A	Saudi Arabia	https://doi.org/10.1016/j.aju.2011.12.001
Rabah et al	2007	Case Report	Robotic Partial Cystectomy	Urology	Saudi Arabia	n/a
Rafique et al	2020	Original Article	Robotic Gynecologic Surgery	Gynecology	Saudi Arabia	https://doi.org/10.29271/jcpsp.2020.03.254
Rapatis et al	2024	Original Article	Robotic Hepatectomy	General Surgery	Saudi Arabia	https://doi.org/10.1016/j.ajt.2024.04.020
Sait et al	2023	Original Article	Robotic Hysterectomy	Gynecology	Saudi Arabia	https://doi.org/10.5144/0256-4947.2023.315
Schulze et al	2022	Original Article	Robotic Liver Transplant	General Surgery	Saudi Arabia	https://doi.org/10.1016/j.hbpd.2022.05.006
Seyam et al	2012	Case Report	Robotic Partial Cystectomy	Urology	Saudi Arabia	https://doi.org/10.5489/cuaj.10103
Seyam et al	2019	Original Article	Robotic Partial Nephrectomy	Urology	Saudi Arabia	https://doi.org/10.15537/smj.2019.1.22782
Sultan et al	2022	Survey	Robotic Surgery Adoption	N/A	Saudi Arabia	https://doi.org/10.1177/23821205211066483
Toffaha et al	2024	Case Report	Robotic Colectomy	General Surgery	Qatar	https://doi.org/10.1007/s10151-024-02988-2
Toffaha et al	2023	Surgical Video	Robotic Colectomy	General Surgery	Qatar	https://doi.org/10.1111/codi.16527
Yousaf et al	2024	Surgical Video	Robotic Colectomy	General Surgery	Qatar	https://doi.org/10.1097/DCR.0000000000002666
Zaghloul et al	2018	Original Article	Robotic Hysterectomy	Gynecology	Egypt	https://doi.org/10.1016/j.jnci.2018.03.003
Zaghloul et al	2016	Case Series	Robotic Colectomy	General Surgery	Egypt	https://doi.org/10.1016/j.jnci.2016.05.003

shown limited knowledge on the benefits of RAS and the extent of its autonomy, with most people not realizing that the surgeon is still in full control [12]. However, despite the data highlighting the increasing diversity of procedures, including complex urological reconstructions, organ transplants, and surgical oncology, it also clearly shows how the use varies significantly [13], with some countries utilizing RAS extensively, while others remain in nascent stages due to cost and infrastructure constraints [2]. Saudi Arabia emerged as the forerunner recently accomplishing the world's first fully robotic liver transplant [14, 15] and robotic heart transplant [16].

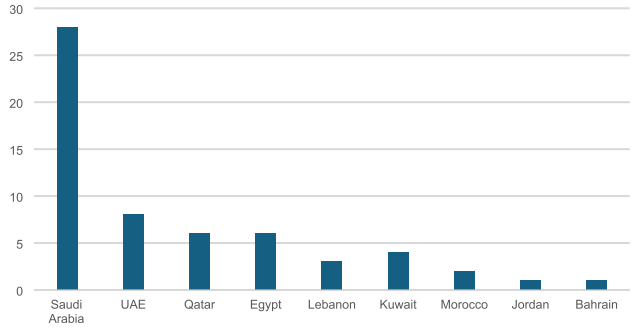

Fig. 2 No. of Robotic Consoles Clinically Available in the Arab World

Research capacity involving robotic surgery

Research and evidence-based medicine is the cornerstone of modern medicine and the key to advancing surgical technique [17]. Robotic surgery research in the Arab world has demonstrated notable strengths but also reveals significant gaps that highlight opportunities for further advancement. Over the past 17 years, 56 publications have contributed to our understanding of the evolution and current state of robotic surgery in the region. However, it is vital to consider that 39/56 were published in the last five years, which shows the renewed interest in RAS in the region. This research consists of a significant number of surgical videos, case reports, and case series, which provide valuable insights into individual experiences and procedural adaptations. Studies have reported the value of single-case reports in shedding light on novel techniques and pathologies [18, 19]. The importance of surgical video publications has also been described, highlighting its role in disseminating knowledge and improving quality, especially when adopting a new technique such as RAS [20, 21]. Initial experiences from tertiary centers and broader perspectives on regional development underscore the growing interest in robotic surgery. Saudi Arabia, Qatar, and the UAE have led in research output, reflecting their investments in robotic platforms and surgical expertise. Saudi Arabia's large volume of robotic hepatectomy cases has made it a world leader in robotic hepatectomies for liver transplant surgery [22]. In addition, there is a paucity of high-quality studies, such as randomized controlled trials, large-scale cohort analyses, or multicenter collaborations, that can provide robust, generalizable data to guide practice and policy. We have seen a recent example in China that witnessed a soar in the number of surgical randomized control trials, notably accompanying the same timeline as the development of locally manufactured robotic consoles [23].

To propel robotic surgery research in the Arab world, efforts should be focused on fostering collaboration among institutions within and beyond the region. Establishing multicenter registries and databases to systematically collect and analyze outcomes would provide a foundation for evidence-based practice [24, 25]. Encouraging longitudinal studies and randomized trials can help evaluate the long-term impact of robotic systems on patient outcomes, cost-effectiveness, and training efficiency. Additionally, leveraging local data, such as the state of robotic consoles and procedural volumes, into structured, peer-reviewed publications can enhance transparency and inform resource allocation.

How to close the global gap

To increase the adoption of robotic surgery in the Arab world, a multipronged approach is essential. Centralizing robotic cases at high-volume centers can enhance surgical outcomes by allowing experienced surgeons to perform complex procedures more efficiently [26, 27]. These centers serve as hubs for skill development and expertise, fostering confidence in robotic systems among surgeons and patients. However, there are other potential negative impacts that need to be examined, such as increasing spatial inequalities in patient access and disadvantaging racial and ethnic minorities [27, 28]. Moreover, establishing national guidelines for robotic surgery indications, such as those developed by the Saudi Urology Association [29], can standardize practices across the region. Such guidelines enable uniform insurance coverage for approved indications, ensuring broader access and reducing financial barriers. Encouraging data collection and outcome reporting from these procedures can further build confidence in robotic technologies by demonstrating their clinical and economic values.

Novel robotic platforms have caused robotic renaissance with renewed excitement and anticipation, which can play a pivotal role in advancing robotic surgical procedures in the Arab world. Systems such as the Versius and Hugo™ RAS, as well as the multitude of systems from China, have expanded the region's capabilities beyond the traditional Da Vinci systems, offering more cost-effective, flexible, and scalable options for healthcare providers [30]. These innovations have enabled smaller- and mid-sized hospitals to adopt robotic technologies and democratize access to advanced surgical care. Growing competition among robotic platforms has also driven innovation and reduced costs, making robotic surgery more accessible across a wider range of medical centers. This evolution not only increases the volume of robotic procedures but also has the potential to strengthen training programs and research in the region. What is important to remember, however, is to create a system agnostic program that monitors the same performance metrics regardless of the system being used, as these are the key elements that directly translate to patient outcomes [31, 32].

Equally critical is the establishment of regional training programs that provide simulation and hands-on experience with robotic systems [33, 34]. These centers can offer

Fig. 3 Live Telesurgery between Doha and Shanghai during the Arab Association of Urology Annual Conference in 2024

tailored training programs for surgeons and staff that focus on both technical skills and patient safety. Partnerships with global robotic leaders, industry stakeholders, and academic institutions can help ensure that these centers are equipped with state-of-the-art technologies and curricula. Additionally, increasing public awareness of the benefits of robotic surgery through education campaigns and patient testimonials can foster demand, further motivating hospitals to adopt these systems [12, 35]. Finally, fostering collaborations between countries in the Arab world to share resources, expertise, and technological advancements can accelerate the adoption process while reducing costs. This comprehensive strategy ensures not only increased adoption but also sustainable integration of robotic surgery in the region's healthcare systems.

Future of robotic surgery in the Arab world

The future of robotic surgery in the Arab world is poised for significant advancements, particularly the integration of telesurgery and tele-mentoring technologies. Telesurgery allows surgeons to operate on patients remotely, a capability that could address disparities in access to advanced surgical care across the region [36]. Tele-mentoring, where experienced surgeons remotely guide less experienced colleagues during live surgeries, is also emerging as a powerful tool to enhance surgical skills and confidence [37, 38]. These innovations are expected to overcome geographical and resource limitations, particularly in underserved areas, by connecting surgeons in remote or less equipped regions with global experts. This paradigm shift not only fosters skill development but also ensures consistent and high-quality care across the region as long as all technical and regulatory requirements are set in place [39].

A milestone in the application of telesurgery in the Arab world was the first robotic telesurgical procedure performed between Morocco and Shanghai: a robotic radical prostatectomy [40]. This groundbreaking procedure demonstrates the feasibility of long-distance robotic surgery and highlights the potential for cross-continental collaboration. Similarly, during the Annual Arab Urology Association meeting in Doha in November 2024, a live robotic surgery demonstration showed a remote connection between Doha and Shanghai (Fig. 3). Soon after, another prostatectomy was performed between Shanghai and Kuwait [41]. These events underscored the region's commitment to adopting cutting-edge surgical technologies and its role in advancing global robotic surgery initiatives. Such collaborations and innovations are expected to drive further integration of telesurgery, establish regional hubs for robotic training, and pave the way for more equitable and readily available robotic surgical care across the Arab world.

Limitations

This study had several limitations. First, the use of a single database (PubMed) for the literature search may have led to the omission of relevant articles indexed in other databases, such as Embase, Scopus, Web of Science, or regional journals, that might not be represented in PubMed. This restriction could introduce selection bias and potentially limit the comprehensiveness of the findings. Second, while leveraging personal connections and data from local distributors helped provide insights into the number of robotic platforms and their utilization, this approach lacks the rigor and verifiability of standardized, publicly available data sources. Such reliance on informal channels may result in incomplete or subjective information, which could affect the accuracy of the conclusions. Future studies should aim to incorporate multiple databases and verify institutional data to provide a more robust and generalizable overview of robot-assisted surgery in the Arab world.

Conclusion

In conclusion, robot-assisted surgery in the Arab World has made remarkable progress. The introduction of new robotic platforms, centralization of high-volume cases, and development of national guidelines can lay a solid foundation for widespread adoption. Innovations in telesurgery and tele-mentoring further highlight the region's readiness to embrace cutting-edge technologies. Regional training centers and partnerships with global industry leaders are essential to address skill gaps and foster local expertise, while public education and insurance coverage reforms drive patient and institutional acceptance. To answer the question, "Robotic-Assisted Surgery in the Arab World: Are we there yet?" The answer is clear: the region is not fully there yet, but it is rapidly advancing, with the foundation firmly in place for a future where robotic-assisted surgery becomes the standard of care across the Arab World.

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Data availability No datasets were generated or analyzed during the current study.

Declarations

Conflict of interest The authors declare that they have no affiliations with or involvement in any organization or entity with any financial interest in the subject matter or materials discussed in this manuscript.

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