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*Research article*

## The impact of telemedicine on cardiac patient outcomes: A study in Saudi Arabian hospitals

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**Abstract: Introduction:** Telemedicine has been increasingly integrated into cardiac care, thus offering remote monitoring and consultation for patients with cardiovascular diseases. It promises to improve patient outcomes, especially in heart failure management, by enabling continuous monitoring of vital signs and facilitating remote patient-provider interactions. This technology has gained particular significance amidst the COVID-19 pandemic, thereby offering a safer alternative to in-person visits. This study assesses the effectiveness of telemedicine in the management of cardiac patients in Saudi Arabia, and reflects on its benefits, challenges, and overall impact on patient outcomes. **Methods:** A retrospective cohort study was conducted to analyze patient records from Saudi healthcare facilities and compare health indicators before and after telemedicine implementation. The study involved cardiac patients who received telemedicine consultations and a control group who received traditional care. Statistical analyses, including the chi-square test, t-test, and ANOVA, were performed to identify differences between the groups while controlling for confounders. **Results:** There were no statistically significant differences between the telemedicine and control groups in terms of blood pressure ( $P = 0.72$ ), heart rate ( $P = 0.65$ ), readmission rate ( $P = 0.54$ ), and medication adherence ( $P = 0.48$ ). The patient satisfaction was slightly higher in the telemedicine group, although the difference was not statistically significant (mean satisfaction score of 3.01 vs. 2.83,  $P = 0.41$ ). **Conclusions:** The introduction of telemedicine did not significantly alter the cardiac patient outcomes compared with traditional in-person care in Saudi Arabia. Although telemedicine offers a promising alternative for patient management, its effectiveness may vary based on the individual patient's needs and specific health indicators. Further research is necessary to explore its full potential and to optimize its application in cardiac care.

**Keywords:** telemedicine; cardiac care; patient outcomes; remote monitoring; healthcare technology; Saudi Arabia

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## 1. Introduction

Telemedicine has shown several benefits in monitoring cardiac patients, particularly in the management of cardiovascular diseases. The use of remote monitoring and telemedicine in heart failure patients with implantable cardioverter-defibrillators has been found to have a positive effect on patient-reported outcomes [1]. Telemedicine, which includes remote disease monitoring and consultation, has been shown to reduce short-term cardiovascular-related mortality and to improve outcomes [2]. In the context of cardiovascular patients, telemedicine has been beneficial to monitor daily body weight, blood pressure, O<sub>2</sub> saturation, heart rate/rhythm, and new invasive direct or indirect assessments of left atrial pressure, which serves as a turning point for therapy adjustments in heart failure patients [3]. Furthermore, telemedicine interventions can continuously monitor patients with cardiovascular diseases, ranging from structured telephone or video support to remote patient monitoring, which allows providers to manage acute and chronic conditions while reducing the patients' travel costs and infection risks [4,5]. Remote echo reading is available in the fields of telecardiology and remote cardiology. These jobs involve the remote interpretation of echocardiograms and the provision of cardiac imaging reporting services. Companies such as National Diagnostic Imaging in virtual health hospitals offer remote echocardiography reading services, with rates starting at \$28 per study [6].

### *1.1. Telemedicine benefits for monitoring cardiac patients*

Telemedicine offers several benefits for monitoring cardiac patients, particularly in the context of the COVID-19 pandemic. Two key advantages of telemedicine include remote monitoring and improved patient engagement. Telemedicine allows for the remote monitoring of patients' vital signs, such as blood pressure and weight, which enables healthcare providers to access a higher quantity and quality of important data. This can help identify and treat conditions such as hypertension and heart failure [3]. Moreover, telemedicine improves patient engagement by providing a faster and more efficient delivery of patient care. Additionally, it allows patients to communicate with clinicians without putting them at risk of infection, which has become particularly important during the pandemic [7].

One of the greatest advantages for patients is the increased convenience and comfort of receiving care at home. It is especially important for cardiac patients with chronic conditions that may need to be regularly monitored. Additionally, telehealth reduces healthcare costs and can be a cost-effective option to remotely manage cardiac risk factors and diseases such as heart failure and coronary artery disease [8]. In telemedicine, expert opinions and treatment plans enables a range of experts to work together to deliver accurate diagnoses and formulate treatment plans for complex heart conditions [9]. In roundup, telemedicine offers opportunities to better integrate remote monitoring into clinical care, improve patient engagement, save time and money for patients, and provide expert opinions and treatment plans for cardiac patients.

### *1.2. Challenges of implementing telemedicine for cardiac patients*

Despite its potential benefits, implementing telemedicine for cardiac patients presents several challenges. One of the key challenges is technological barriers, and the adoption of telemedicine faces resistance to change and technological barriers. While telemedicine technologies provide an ideal platform contact and connect with patients without having to travel or wait at clinics for long hours, there are certain risks associated with virtual consultations. Additionally, the percolation of technology becomes easier if patients accept this mode of healthcare delivery [10]. Alternatively, patients with cardiovascular diseases may face difficulties in obtaining vital signs and performing clinical examinations and diagnostic procedures through telemedicine. Moreover, the cancellation of telemedicine appointments and challenges in obtaining medications have been reported as significant obstacles for patients during the COVID-19 pandemic [7]. Limitations of telemedicine consultations may change clinician workflows, assessments, and consultation dynamics, and the lack of physical examination is deemed to be a significant downside. While patients may not perceive a physical examination as a vital part of the consultation, it remains a challenge for clinicians to assess patients and make clinical decisions without the ability to conduct a physical examination [11]. Telehealth is an effective option to diagnose, educate, and follow people with health issues, including cardiovascular diseases. However, its use in rural and under-resourced communities remains a challenge. The acceptance of telemedicine by patients and healthcare providers is crucial for its successful implementation [12]. In summary, the challenges of implementing telemedicine for cardiac patients include technological barriers, patient-related challenges, limitations in clinical assessments, and issues related to accessibility and acceptance [13].

### *1.3. Best practices for telemedicine implementation in cardiac care*

The implementation of telemedicine in cardiac care can be challenging, but the following best practices can help overcome these challenges and improve patient outcomes. One of the best practices for telemedicine implementation in cardiac care includes establishing clear goals and strategies, which is essential for successful telemedicine implementation. This includes identifying the target population, defining the scope of services, and selecting appropriate technologies and equipment [14]. Healthcare providers and patients need adequate trainings and support to use telemedicine effectively. This includes trainings on the use of technology, equipment, and software, in addition to providing technical support and troubleshooting [11]. Ensuring privacy and data security are critical in telemedicine implementation. Healthcare providers must ensure that patient data are secure and protected from unauthorized access or disclosure. This includes complying with the Health Insurance Portability and Accountability Act (HIPAA) regulations and implementing appropriate security measures [15]. Technological barriers can hinder telemedicine's implementation. Healthcare providers must ensure that patients have access to the necessary technology and equipment, such as smartphones, tablets, and computers, and that they are comfortable using them. Additionally, healthcare providers must ensure that their own technology infrastructure is adequate to support telemedicine services [16]. Monitoring and evaluating outcomes are essential to assess the effectiveness of telemedicine implementation. This includes tracking the patient outcomes, satisfaction, and cost-effectiveness. Healthcare providers can use this information to improve and refine telemedicine services [17]. Briefly, the best practices for telemedicine implementation in

cardiac care include establishing clear goals and strategies, ensuring adequate training and support, ensuring data security and privacy, addressing technological barriers, and monitoring and evaluating outcomes.

The purpose of this study is to evaluate the effectiveness of telemedicine in managing cardiac patients in Saudi Arabian hospitals. Specifically, the study aims to assess the impact of telemedicine on key health outcomes, including blood pressure, heart rate, hospital readmission rates, medication adherence, and patient satisfaction. By comparing these outcomes between patients who received telemedicine consultations and those who received traditional in-person care, this research seeks to provide insights into the clinical effectiveness of telemedicine in cardiac care within the context of Saudi Arabia.

## 2. Methodology

A retrospective cohort study was conducted to investigate the impact of telemedicine on cardiac patient outcomes in Saudi Arabia. This study analyzed patient records from Saudi healthcare facilities to compare cardiac health indicators before and after the implementation of telemedicine services. The study population included cardiac patients who have received telemedicine consultations and a control group who received traditional in-person care, thus ensuring a balanced comparison. Key data points were collected, including blood pressure, heart rate, electrocardiogram readings, hospital readmission rates, medication adherence, and patient-reported outcomes. The timeframe for data collection spanned 1–2 years before and after the telemedicine implementation.

This study employed a retrospective cohort design to evaluate the impact of telemedicine on cardiac patients in Saudi Arabia. The study population includes two groups: one who received telemedicine consultations and the other who received traditional in-person care. A total of 200 adult patients with diagnosed cardiovascular diseases, such as heart failure or coronary artery disease, were included in the study, with 100 patients in each group.

Patients in the telemedicine group received care through virtual consultations via video calls, phone calls, and remote monitoring devices. These technologies tracked key health indicators, including blood pressure, heart rate, and oxygen saturation. A secure telemedicine platform that was compliant with data privacy regulations was used to ensure safe patient-provider communication.

Patients in the control group received standard in-person care at designated healthcare facilities. Routine clinical evaluations, physical examinations, and laboratory tests were conducted during their visits.

Patients in both groups were followed for 12 months. The measured outcomes included blood pressure, heart rate, hospital readmission rates, medication adherence, and patient satisfaction. Statistical analyses, including t-tests and chi-square tests, were used to compare the groups, with significance set at  $P < 0.05$ .

The inclusion criteria included the following:

Adult patients (aged  $\geq 18$  years) who were diagnosed with cardiovascular diseases, including heart failure, coronary artery disease, and arrhythmias;

Patients who received at least one telemedicine consultation during the study period;

Patients with available baseline data for key health indicators, including blood pressure, heart rate, and hospital readmission rates; and,

Patients who provided informed consent to participate in the study and allowed access to their medical records.

The exclusion criteria included the following:

Patients under 18 years of age;

Patients with incomplete or missing medical records or insufficient data for baseline and follow-up measures;

Patients with complex comorbid conditions (e.g., cancer and advanced chronic obstructive pulmonary disease) which confound the outcomes of cardiovascular management; and,

Patients who were unable or unwilling to participate in telemedicine consultations or whose technological access was insufficient to support telemedicine use.

The statistical analyses included descriptive statistics to summarize the patient demographics and baseline health indicators, and comparative analyses were performed to identify differences in the health outcomes between the two groups. Statistical tests, such as chi-square, t-test, and ANOVA, were employed to determine the significance of these differences, and a regression analysis was used to control for confounders such as age, sex, and disease severity. The statistical methods used in the study will be described in more detail. This includes specifying the exact tests applied (e.g., chi-square test, t-test, ANOVA) to compare the outcomes between the telemedicine and control groups. Additionally, the level of statistical significance (e.g.,  $P < 0.05$ ) will be clearly stated to clarify how differences were recognized as statistically significant.

The study prioritized ethical considerations to ensure patient data confidentiality and compliance with relevant ethical guidelines. Limitations, such as the retrospective nature of the study and a potential selection bias, are acknowledged. Finally, the findings which are reported in a detailed manner, with implications for future cardiac care and telemedicine practices in Saudi Arabia, contribute valuable insights into the field of telemedicine in cardiac patient management.

### 3. Results

The study included 100 patients in both the telemedicine and in-person groups. The average age was similar between the groups, with 53.15 years for the telemedicine group and 54.19 years for the in-person group. In terms of gender, 60% of the telemedicine group and 58% of the in-person group were male. Regarding their underlying conditions, 45% of the telemedicine patients had heart failure compared to 43% for the in-person group. Additionally, 35% of the telemedicine group had coronary artery disease, which was slightly lower than the 37% for the in-person group. Arrhythmias were present in 20% of telemedicine patients and in 18% of in-person patients. This comparison highlights the similar baseline characteristics of both groups.

The study indicated notable similarities in the mean values between the control group and the telemedicine group across various metrics. As Table 1 shows, there were no substantial differences in blood pressure, heart rate, readmission rate, medication adherence, and patient satisfaction scores between the telemedicine and control groups.

**Table 1.** Descriptive analysis for the study variables.

Metric	Statistic	Control group	Telemedicine group
Age	Mean	54.19	53.15
	Median	54.00	52.00
	Standard deviation	14.70	14.89
Blood pressure before	Mean	100.49	99.69
	Median	101.41	99.28
	Standard deviation	10.92	10.66
Blood pressure after	Mean	100.57	99.64
	Median	100.37	100.93
	Standard deviation	9.70	10.33
Heart rate before	Mean	80.05	79.49
	Median	79.77	79.46
	Standard deviation	9.72	9.11
Heart rate after	Mean	80.97	78.93
	Median	81.61	78.98
	Standard deviation	10.57	9.57
Readmission before	Mean	0.27	0.31
	Median	0.00	0.00
	Standard deviation	0.45	0.46
Readmission after	Mean	0.39	0.36
	Median	0.00	0.00
	Standard deviation	0.49	0.48
Medication adherence before	Mean	0.52	0.48
	Median	1.00	0.00
	Standard deviation	0.50	0.50
Medication adherence after	Mean	0.50	0.47
	Median	0.50	0.00
	Standard deviation	0.50	0.50
Patient satisfaction before	Mean	2.78	2.89
	Median	2.50	3.00
	Standard deviation	1.41	1.39
Patient satisfaction after	Mean	2.83	3.01
	Median	3.00	3.00
	Standard deviation	1.42	1.49

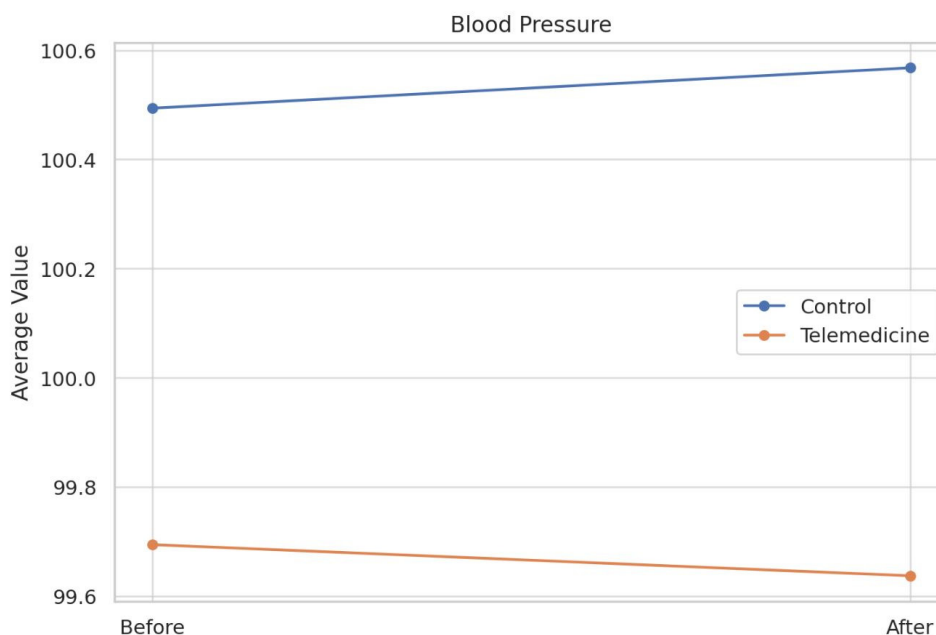
The results presented highlight notable similarities in the mean values between the control group and the telemedicine group across various metrics. Based on the measured metrics, one can conclude that the introduction of telemedicine did not significantly alter the cardiac patient's outcomes compared to traditional in-person care. The call for further analyses and exploration acknowledges the

nuanced aspects of the impact of telemedicine on the cardiac healthcare landscape in Saudi Arabia, thus suggesting a commitment to ongoing research and adaptation to evolving healthcare dynamics.

The study results indicated that telemedicine had no significant impact on blood pressure changes or patient satisfaction scores. However, as shown in Table 2, specific predictors of patient satisfaction were identified, thus highlighting the importance of monitoring heart rate changes and considering the initial patient satisfaction levels. These findings provide valuable insights into the evolving landscape of telemedicine for cardiac patient management in Saudi Arabia. This study emphasizes the need for continued research and refinement of telemedicine practices to optimize the cardiac care outcomes. The Summary encapsulates the key findings, thereby emphasizing that telemedicine had no significant impact on blood pressure changes (Figure 1) or patient satisfaction scores. However, the identification of specific predictors of patient satisfaction, such as monitoring heart rate changes and considering the initial patient satisfaction levels, provides a nuanced understanding. These findings provide valuable insights into the evolving landscape of telemedicine for cardiac patient management in Saudi Arabia. This study appropriately emphasizes the need for continued research and refinement of telemedicine practices to optimize outcomes in cardiac care, thus reflecting a forward-looking approach to healthcare innovation.

**Table 2.** Compare the health metrics effects with telemedicine.

Metric	Impact of telemedicine	Key findings
Blood pressure change	No significant effect	Telemedicine did not significantly affect the change in blood pressure compared to the control.
Patient satisfaction after use telemedicine	No significant effect	Telemedicine did not significantly affect patient satisfaction scores after the study.
Significant predictors of patient satisfaction	Change in heart rate, patient satisfaction before use telemedicine	Heart rate change and initial patient satisfaction were significant predictors of satisfaction after the study.



**Figure 1.** Comparative blood pressure between control and telemedicine groups.

#### 4. Discussion

The introduction highlighted the transformative potential of telemedicine in the realm of cardiac care, thus underscoring its positive impact on the monitoring of cardiovascular patients. The utilization of remote monitoring and telemedicine technologies in patients with heart failure has demonstrated positive outcomes, thus contributing to patient-reported well-being and potentially reducing short-term cardiovascular-related mortality. The capacity of telemedicine to monitor various vital signs, including body weight, blood pressure, O<sub>2</sub> saturation, heart rate/rhythm, and left atrial pressure, reflects its comprehensive role in managing complex conditions of heart failure. Moreover, the diverse spectrum of telemedicine interventions, ranging from structured telephone or video support to remote patient monitoring, signifies their versatility in managing both acute and chronic cardiovascular conditions.

Telemedicine has been found to have a definite role in the management of heart failure when combined with both remote monitoring and patient consultation to optimize treatments. A systematic review and meta-analysis found that telemedicine was associated with reduced cardiovascular mortality and hospitalization. The remote monitoring of body weight, blood pressure, heart rate, and self-reported health were associated with a reduction in the rate of hospitalization for HF (Heart Failure). Additionally, telemedicine has been found to be useful in the early detection of technical issues with cardiac implantable electronic devices (CIEDs) and cardiac arrhythmias. Telemonitoring biosensors and devices based on advanced technologies and interventional cardiology have been developed to make care more accessible, to increase overall healthcare, and to improve outcomes. Telemedicine during the COVID-19 pandemic allowed patients to safely stay at home and ranged from virtual visits and hospital connections to ongoing monitoring of the patients [2,3,8]. This research delved into the impact of telemedicine on monitoring cardiac patients, specifically in the context of cardiovascular diseases. This study explored the benefits, challenges, best practices, and outcomes



associated with the implementation of telemedicine in Saudi Arabia, thus offering valuable insights into its role in cardiac patient management.

Although our study did not find significant short-term cardiac patient benefits connected to telemedicine, one needs to consider the greater role that telemedicine would play within its complete potentiality and scope for preventive care. Various studies have demonstrated how telemedicine reduced long-term cardiovascular mortality, prevented further disease progression, and realized optimal management of chronic conditions based on early intervention and follow-up monitoring.

For example, a review by Kuan et al. showed that telemedicine prevented hospital admissions in heart failure patients through an early detection of deterioration and a timely modification of treatments [2]. Additionally, telemonitoring of blood pressures and heart rates showed great promise to prevent acute cardiac events through early interventions [1].

These studies further reinforce the perception that telemedicine is not only a tool used to manage present conditions, but to also prevent complications and promote general cardiovascular health. Our study's focus on short-term outcomes in a specific region may not fully capture these long-term benefits, and further research is necessary to more comprehensively explore this preventive potential of telemedicine. With these considerations, one recognizes the growing body of evidence that supports the effectiveness of telemedicine in the prevention of cardiovascular diseases. Although our results were modest with respect to immediate clinical outcomes, they represent a basis for future studies that might consider the broader and longer-term use of telemedicine in cardiac management.

In addition to the findings of our study, it is important to acknowledge the growing body of research that highlights the role of digital health technologies in enhancing patient and caregiver engagement, particularly in the management of chronic conditions, such as heart failure. Albulushi et al. [18] provided valuable insights into how digital health tools could be leveraged to improve communication between patients, caregivers, and healthcare providers. Their study emphasized that telemedicine not only facilitates continuous monitoring, but also fosters the increased involvement of patients and caregivers in the management of heart failure, which could lead to an improved adherence to treatment plans and improved outcomes.

These findings complement our results by reinforcing the broader potential of telemedicine beyond clinical metrics, such as heart rate or blood pressure. While our study focused on immediate health indicators, the long-term benefits of increased patient engagement, as described by Albulushi et al., provide additional support for the ongoing adoption and refinement of telemedicine in cardiac care [18].

## 5. Recommendations

Based on the findings and insights from this study on the impact of telemedicine on monitoring cardiac patients, the following recommendations are proposed:

**Enhanced Technology Integration:** Encourage healthcare facilities to further integrate and upgrade their telemedicine technologies. This includes ensuring high-quality video conferencing tools, reliable remote-monitoring devices, and user-friendly interfaces for both patients and providers.

**Patient and Provider Education:** Develop comprehensive educational programs for patients and healthcare providers about the use of telemedicine in cardiac care. This should include instructions

on operating the technology, understanding its limitations, and recognizing when in-person visits are necessary.

**Customized Telemedicine Solutions:** Recognize the diversity in the patient's needs and conditions by customizing telemedicine approaches. One should tailor services to individual patient profiles, thereby considering factors such as age, technological literacy, and specific cardiac conditions.

**Expand Accessibility:** Work towards reducing technological and infrastructural barriers that patients may face, especially in rural or underserved areas. One should ensure that patients have the necessary equipment and internet connectivity to effectively utilize telemedicine services.

**Policy and Guidelines Development:** Develop clear policies and guidelines to manage and standardize telemedicine practices in cardiac care. This includes protocols for patient privacy, data security, and emergencies.

**Quality Assurance and Improvement:** Implement quality assurance mechanisms to continuously monitor and evaluate the effectiveness of telemedicine services. One should use patient feedback and health outcome data to make informed improvements to the telemedicine delivery model.

**Research and Development:** Encourage ongoing research to explore the full potential of telemedicine in cardiac care, thereby focusing on long-term outcomes, patient satisfaction, cost-effectiveness, and comparisons with traditional care methods.

**Collaboration and Networking:** Promote collaboration among healthcare providers, technology experts, and policymakers to share best practices, innovations, and research findings related to telemedicine in cardiac care.

**Focus on Preventive Care:** Utilize telemedicine for preventive care by regularly monitoring at-risk patients, providing lifestyle and dietary guidance, and managing medication adherence to prevent acute cardiac events.

By implementing these recommendations, the healthcare community can enhance the effectiveness of telemedicine in cardiac care, thus leading to improved patient outcomes, a greater healthcare accessibility, and more efficient medical systems.

## **6. Limitation**

However, the impact of telemedicine on cardiac patient monitoring has several limitations. It relies on a retrospective design, which may include a selection bias and limit the causality inference. The focus of this study on a specific geographic region may not be generalizable to other settings or populations. Technological disparities among patients, such as access and literacy, may have influenced the results. The study period may not have captured the long-term effects of telemedicine, and patient self-reporting could have introduced bias. Lastly, rapid advancements in telemedicine technologies might outdate some findings, thus necessitating continual research to remain relevant. Several factors may explain the lack of significant differences between telemedicine and the control groups. Future studies with larger samples sizes and a longer duration will combat our relatively short duration of telemedicine implementation (1–2 years), which may have limited our ability to capture long-term effects and significant differences. Additionally, both the patients and the providers might have needed time to adjust to the new technology, affecting its early effectiveness. Finally, the health indicators measured (e.g., blood pressure and heart rate) may not have been the most responsive to telemedicine in the short term.

## 7. Conclusions

Based on the measured metrics, the results suggest that the introduction of telemedicine did not significantly alter cardiac patient outcomes when compared with traditional in-person care. Further analyses and explorations may be necessary to comprehend the nuanced aspects of the impact of telemedicine on the overall cardiac healthcare landscape in Saudi Arabia. A summary table that displays the mean, median, and standard deviation for each metric in the dataset was included.

### Author contributions

All the five authors contributed equally to this work. All authors were involved in all research phases, including the study's conception and design, data retrieval, collection, and analysis, and the drafting and critical revision of the manuscript for important intellectual content. All authors approved the final version of the manuscript to be published and agreed to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved.

### Use of AI tools declaration

The authors declare they have not used Artificial Intelligence (AI) tools in the creation of this article.

### Ethics approval of research and informed consent

The study was approved by the Aseer Ethics Committee or Institutional Review Board at ministry of health and we confirm that we have obtained the patients' informed consent and Ethical approval prior to study.

### Conflict of interest

The authors declare no conflict of interest.

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