

REVIEW

The Use of Telemedicine in Surgical Care: a Systematic Review

Abdulmajid Asiri¹, Sara AlBishi¹, Wedad AIMadani², Ashraf ElMetwally³, Mowafa Househ³

¹King Saud bin Abdulaziz University for Health Sciences, Riyadh, Kingdom of Saudi Arabia

²Office of Research, King Abdullah International Medical Research Center, King Saud bin Abdulaziz University for Health Sciences, Ministry of National Guard Health Affairs, Riyadh, Kingdom of Saudi Arabia

³College of Public Health and Health Informatics, King Saud bin Abdulaziz University for Health Sciences, Ministry of National Guard, Health Affairs, Riyadh, Kingdom of Saudi Arabia.

Corresponding author: Abdulmajid Yousef Asiri, MD. King Saud bin Abdulaziz University for Health Sciences, Riyadh, Kingdom of Saudi Arabia. ORCID ID: <https://orcid.org/0000-0003-2754-3139>. E-mail: mjyasiri@outlook.com.

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ABSTRACT

Introduction: Telemedicine describes a healthcare service where physicians communicate with patients remotely using telecommunication technologies. Telemedicine is being used to provide pre-/postoperative surgical consultation and monitoring as well as surgical education. **Aim:** Our purpose was to investigate the broad range of telemedicine technologies used in surgical care. **Material and methods:** MEDLINE, EMBASE, CINAHL, and Science Direct were searched for available literature from inception to March 30, 2018 with no language restrictions. The search terms included: cell phones, telemedicine, telecommunications, video, online, videoconferencing, remote consultation, surgery, preoperative, perioperative, postoperative, and surgical procedures. Studies were included if they used telemedicine in surgery for pre-, peri-, or post-surgery periods, and if they compared traditional surgical care with surgical telemedicine. We excluded case series, case reports, and conference abstracts from our review. **Results:** A total of 24 studies were included in our review. The study found that the use of telemedicine in preoperative assessment and diagnosis, evaluation after surgery and follow-up visits to be beneficial. Patients reported benefits to using telemedicine such as avoiding unnecessary trips to hospitals, saving time and reducing the number of working days missed. **Conclusion:** Telemedicine in surgical care can provide benefits to both patients and

Keywords: Telemedicine; surgical procedure; satisfaction; monitoring.

1. INTRODUCTION

Since the 1970s, the term ‘telemedicine’ has been used to describe a healthcare service where physicians can communicate with patients remotely using telecommunication technologies (1, 2). The roots of this evolving technology began in the early 20th century, when Willem Einthoven, a Dutch physiologist, established the first electrocardiograph in his laboratory in Leiden. Einthoven recorded the electrical cardiac signals of patients in a hospital 1½ km away by using a string galvanometer and telephone wires. Today, the Institute of Medicine (IOM) defines telemedicine as “the use of electronic information and communications technologies to provide and support health care when distance separates participants” (3).

In surgical care, telemedicine technologies have been used to provide pre/postoperative surgical consultations and monitoring, as well as surgical teleconferencing and education across bor-

ders (4-8). In 1998, Robie et al. found that telemedicine provided an accurate diagnosis for neonatal surgical consultations (9). Bullard et al. reported that mobile-phone images of CT scans appeared to be sufficient for neurosurgeons to make decision about their patients and reduced the need to transfer patients from referring hospitals by 30–50% (10). Another study found that using telemedicine for postoperative follow-up after cleft lip/cleft palate repair saved significant travel time and distance and allowed access to specialty services within a larger radius than would be possible for a clinical appointment (11). Furthermore, Urquhart et al. reported that telemedicine for routine postoperative follow-up after parathyroidectomy was safe and effective (12).

Although several studies have investigated specific modes of technology for telemedicine or the use of telemedicine within a particular surgical subspecialty, none have examined the use of telemedicine in surgical care from a

broad perspective. The purpose of this systematic review is to provide an overview of telemedicine use in surgical care.

2. METHODS

Publication search

A detailed search protocol was designed. The analysis and eligibility criteria were stated and documented according to Preferred Reporting Items for Systematic reviews and Meta-Analyses (PRISMA) (13). A systematic search was conducted in MEDLINE, EMBASE, CINAHL, and Science Direct from the inception of the database up to March 2018. Keywords and medical subject headings relating to the condition and treatment were identified prior to initiating the search. Search terms included: cell phones, telemedicine, telecommunications, video, online, videoconferencing, remote consultation, surgery, preoperative, perioperative, postoperative, surgical procedures, operative, and monitor. All relevant article references were also manually searched to identify other related studies.

Eligibility

We systematically reviewed published studies according to originality, interventions, comparators, and study design. All the included articles addressed telemedicine use and surgery for pre-, peri-, or post-surgery periods. All types of surgery and comparative and non-comparative studies, such as randomized controlled trials and observational studies were included. We excluded reviews, case series, case reports, and conference abstracts. We also excluded robotic surgery studies.

Data extraction

Two authors (AA and SA) independently reviewed the abstracts for inclusion or exclusion. For each study, they independently extracted: year; setting; study design; population; and type of surgery. The authors (AA and SA) also recorded the type of telemedicine technology used, results, and limitations for each study.

3. RESULTS

Included studies

The primary search identified 6678 studies from the online databases and hand searching identified a further eight (Figure 1). After title screening, 84 articles were retrieved for full-text assessment. From those, 24 articles were included in our systematic review. Sixty articles were excluded for the following reasons: different intervention or outcome; review of the use of telemedicine; the advantage of installing telemedicine in healthcare; systematic review; case reports of patients that included type of telemedicine used; and surveys of patients or healthcare providers on the use of telemedicine in their institutions.

Of the included studies, three were randomized controlled trials, three were pilot studies, four were retrospective studies using data retrieved from medical records, and the remainder were prospective observational studies. Table 1 summarizes the characteristics of the included studies.

Protocol for included studies

The types of telemedicine technology used in the studies were mainly teleconferencing, mobile phone and tablet applications (for example, Skype), digital images, and text messaging.

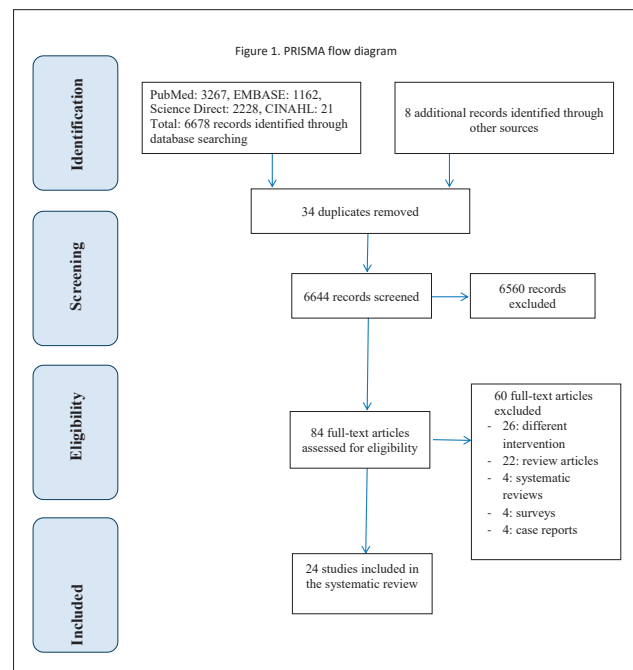


Figure 1. PRISMA flow diagram

There were only three types of telemedicine protocols reported in the included studies. The first was for preoperative assessment, diagnostic purposes, or for consultation with another surgical department (9, 14–22). The second involved using telemedicine for postoperative wound assessment, from either a photograph of the surgical wound, via a health-monitoring machine, or an SMS from patients if they had an unusual symptom (23–31). The third used tele-monitoring in place of conventional clinics for follow-up (12, 32–35). Almost all of the studies included direct contact from patient to healthcare provider, which meant that, to be included in the studies, patients had to have Internet access. Some studies provided patients with smartphones or tablets so they could take part in the study. Only one study, by Demartines et al. (14), involved communication between two hospitals, which was part of the diagnostic process for patients undergoing digestive or endocrine surgery.

Clinical outcome

Studies that reported telemedicine for preoperative or diagnostic processes, such as Lee, et al., reported 100% agreement between the telemedicine technology and the on-site preoperative diagnostic results (15). Hands, et al. referred patients to the vascular surgery clinic via telemedicine and found the introduction of alternative management plans to be beneficial for consultants and patients (16). Demartines et al. discussed the accuracy of judging organ structure and function before digestive or endocrine surgery (14). Three studies found that preoperative diagnosis via telemedicine was as accurate as interventions carried out in usual conventional clinics (9, 17, 19). Wallace et al. used telemedicine to allow different surgical teams to evaluate patients' injuries before they went into the operating room. The studies found that technology reduced unnecessary transfers to the neurosurgical department and also reduced complications during surgery (18, 20). Postuma and Loewen found that patients could use videoconferencing from their home desktop computer for plastic surgery consultations, saving them a trip to the hospital (21).

No.	First author, year	Study design/setting	Type of surgery included	Intervention	Comparison	Results
1	Bednarski BK (16), 2018	Prospective trial was conducted at a single academic institution	Ileostomy	Videoconferencing for postoperative assessment of ileostomy output patients post-discharge assessment using iPad 2 tablets and FaceTime	Usual care	Technology and telemedicine enabled greater connectivity between patients and their providers
2	Demartines N (17), 2000	Prospective cohort study in which two hospitals, 120 miles apart, were connected via integrated services digital network (ISDN) tele-conferencing units	Digestive or endocrine surgery	Tele-transmission (tele-diagnosis) for judgment of organ structure and function pre-endocrine or gastric surgery	Direct vision (direct diagnosis)	Telemedicine increased and simplified the exchange and diffusion of medical knowledge, education, and information
3	Willard A (18), 2018	Prospective cohort study design	Different pediatric surgeries	Video was used to visualize outpatient infants for follow-up post-surgery evaluation of wounds and medical equipment, such as nasogastric and gastrostomy tubes	Usual care	Helped the team diagnose infection and evaluate patients' sleep environment and follow-up readings on medical equipment
4	Martínez-Ramos C (19), 2009	Pilot study	Ambulatory surgery	Using GPRS mobile-phone-based telemedicine system for the assessment of postoperative surgical wounds	Usual care	Improved home postoperative follow-up after ambulatory surgery
5	Robaldo A (20), 2010	Prospective study	Carotid endarterectomy procedures	Discharge with mobile-phone monitoring 'electronic BP' and web-based videoconferencing, monitoring the patients every 4 h for 2 days	Inpatient monitoring	Telemedicine appeared feasible and useful in carotid endarterectomy and may have other applications in vascular surgery care.
6	Wirthlin DJ (27), 1998	Prospective study	Vascular surgery	Digital images to assess patients' wounds	Bedside examination	Feasible on the basis of high concordance between remote and on-site surgeons regarding wound evaluation and management
7	Urquhart AC (12), 2011	Prospective non-controlled study at a tertiary medical center of a cohort of 39 patients	Parathyroidectomy	Postoperative telehealth service using tablet computers to replace clinic visits	On-site examination	Telemedicine has the potential to greatly expand and improve cost-effective, high-quality care
8	Lee S (15), 2003	Prospective cohort study	General surgery	Evaluation of patients via low-bandwidth telemedicine. Pre-screening was performed with digital image capture of pertinent physical findings or radiographs	On-site preoperative diagnosis	Internet-based surgical pre-screening was inexpensive and effective. The agreement of remote and on-site preoperative diagnosis was 100%
9	Hands L (16), 2004	Prospective cohort study	Vascular surgery	Telemedicine clinic appointment to enable diagnosis and management decisions for patients referred to vascular surgery	Conventional hospital outpatient appointment	Videoconference provided an important means of transmitting additional information. It also allowed patient and consultant to be introduced and possible alternatives for management to be discussed
10	Sudan R (17), 2011	Prospective study	Bariatric surgery	Pre- and postoperative management were linked by teleconferencing and a computerized patient record system to evaluate and educate remote patients	Usual care	The preoperative evaluation process was considered adequate
11	Robie DK (9), 1998	Prospective study	Pediatric surgery	Teleconsultation using desktop-computer-based system for preoperative diagnosis	Usual care	In all cases, the diagnosis was accurate, and appropriate plans for further diagnostic studies and treatment recommendations were made
12	Segura-Sampedro JJ (28), 2017	Prospective pilot study	Appendectomy	Telemedicine-based evaluation (images of the surgical wounds of cases obtained via their own mobile devices)	Face-to-face consultation	Feasibility of telemedicine for the follow-up of wounds after emergency surgery
13	Scerri G (18), 1999	Prospective study	Plastic surgery	Using digital camera to obtain specialist opinions in plastic surgery	Usual care	Telemedicine system was helpful in the management of plastic surgery and telemedicine images were reliable for diagnostic purposes
14	Wood EW (19), 2016	Retrospective study	Maxillofacial surgery	Telemedicine consultations to provide accurate diagnosis and treatment plans for patients undergoing surgical treatment with anesthesia	Usual care	Telemedicine provided more timely access from primary care to specialist services, improved communication between providers, healthcare provider education, and increased cost effectiveness
15	Wallace D (20), 2008	Retrospective study that was continued prospectively.	Acute plastic surgical trauma and burns	Management of patient with telemedicine to assess injuries	Usual care	Telemedicine systems proved useful in reducing unnecessary transfers in neurosurgical emergencies, and reduced mortality, complications, and costs in intensive care

16	Postuma R (21), 2005	Retrospective study	Pediatric surgery	Telephone-based videoconferencing for plastic surgery consultations	In-person contacts in pediatric surgery ambulatory-care patients	Telehealth assessments took longer than in-person visits, but over time and with familiarity, the duration of telehealth and in-person sessions became the same.
17	Ellison LM (29), 2004	Prospective randomized controlled trial	Laparoscopic or percutaneous urologic procedures	Web-based videoconferencing system used for postoperative assessment 'tele-rounding'	Standard care	Tele-rounding was associated with greater patient satisfaction with postoperative care
18	Schlachta CM (22), 2009	Prospective study	Laparoscopic colon surgery	Six tele-mentored group colon resections	20 open colon resections	Mentored cases took longer but resulted in a shorter hospital stay. Wound complication occurred in one tele-monitored patient, with six in the comparator group.
19	Rao R (30), 2012	Retrospective review	Breast surgery	Text messaging between patient and surgeon regarding surgical drain output	Usual care	Text messaging protocol reduced number of clinic visits (2.82 vs 3.65 in first 30 days, $p=0.0004$), and decreased overall days of drain requirement (9.67 vs 12.45, $p=0.013$).
20	McGillicuddy JW (32), 2013	Randomized control trial	Transplant surgery	Smartphone-based (Droid X, Motorola) medication adherence and blood pressure self-management system using a wireless Bluetooth blood pressure monitor (FORA D15b, Fora Care Inc) and a wireless GSM electronic medication tray (Med Minder, Maya, Inc.) in renal transplant recipients to improve long-term graft outcomes and better management of comorbidity	Standard care	Patients in the smartphone group had better medication adherence ($p<0.05$) and lower systolic blood pressure $p=0.009$ at 3 months compared with standard care patients; physicians made more medication adjustments in the smartphone group; patients using the smartphone system reported high satisfaction and ease of use with the system.
21	Sharareh B (33), 2014	Non-randomized prospective study	Orthopedic surgery	Online video-conferencing via Skype used for routine postoperative follow-up after total joint arthroplasty	In-person clinical visits	Telemedicine allowed effective communication and reduced the need to call the clinic for medical reasons
22	Canon S (31), 2014	Retrospective study	Pediatric urology surgery	Online video-conferencing (unspecified commercial platform) from remote clinic site for routine postoperative follow-up after hypospadias repair, epispadias repair, circumcision revision, correction of buried penis, orchiopexy, orchietomy, hernia repair, or hydrocelectomy	In-person follow-up	Postoperative assessment was considered approximately equivalent between the two groups as the number of follow-up appointments was similar and no additional on-site visits were needed post-telemedicine
23	Viers BR (34), 2015	Randomized controlled trial	Urological surgery	Online video-conferencing via internally designed interface using video software and SBR Health software for routine follow-up after radical prostatectomy	In-person visit	Equivalent clinic efficiency between videoconference and in-person visits; high patient and provider satisfaction in the videoconference group; no acute urologic issues at 3 months follow-up; significant travel time and distance saved in videoconference group.
24	Sathiyakumar V (36), 2015	Prospective randomized control trial (pilot study)	Orthopedic trauma	Telemedicine follow-up appointments via Skype	In-person follow-up visit	No difference in satisfaction. Patients were accepting of Skype follow-up and saved significant travel time and distance.

Table 1. Characteristics of the included articles in the study analysis

Four studies involved postoperative wound assessment via either photographs or teleconferencing. The authors found that a mobile-phone-assisted system improved postoperative follow-up and decreased the need for patients to attend ambulatory care for routine wound checks (25, 27, 28, 33, 36, 37). The third type of intervention was telemedicine for usual follow-up. Four studies used teleconferencing for usual postoperative care assessment and found that the technology enabled strong connectivity between patients and the healthcare provider (23, 31, 34, 35). Two studies described the use of vid-

eoconferencing via a mobile phone for remote patient monitoring using an electronic blood pressure monitoring device or for monitoring surgical drains and found that it was very beneficial for both parties (26, 30). One study described the use of telemedicine to see infants for follow-up to check on their sleep environment, readings on medical equipment, and for early detection of infection (24). Finally, McGillicuddy et al. reported that using smart phones led to improved long-term graft outcomes and better management for comorbidities compared with standard surgical care. The study found

that telemedicine was associated with better medication adherence, lower systolic blood pressure and faster medication adjustment (32).

Patients' satisfaction and money saved

One study, by Ellison et al. investigated patients who had undergone urological procedures; patients had, as the main outcome, patient satisfaction with the 'tele-visit' compared with usual care. More than 95% of patients in the tele-visit arm thought their care was good and considered that this should be the future for patient care (29). Nine other studies reported patients' satisfaction with telemedicine (12, 17, 24, 25, 27, 29, 32-34). All studies reported high satisfaction using telemedicine, with scores ranging from 4.5 to 5 out of 5. Two studies that described patient satisfaction included reference to money saved (12, 19). Most of the patients' comments were about avoiding unnecessary trips to hospitals, saving time and reducing the number of working days missed (24, 25).

4. DISCUSSION

Telemedicine technology is becoming an essential tool in healthcare delivery (2, 3, 38-43). This systematic review focused on the use of telemedicine in surgical care. We included studies comparing on-site consultations with telemedicine to enable us to draw practical conclusions about the use of this technology. Our study found that telemedicine was a useful technology to be used in surgical care according to all of the studies included in our review. The majority of studies reported the use of telemedicine between patients and healthcare providers and only one study compared telemedicine use between two hospitals.

The studies included in the review demonstrated the use of telemedicine in preoperative assessment and diagnosis, evaluation after surgery and follow-up visits to be beneficial. For postoperative evaluation and follow-up, five studies found videoconferencing feasible and useful. Digital images were suitable for the assessment of surgical wounds. According to Martínez-Ramos et al. telemedicine helped physicians assess local complications and avoid unnecessary hospital visits (25). Regarding preoperative diagnosis, telemedicine via internet-enabled computers was beneficial in two studies (9, 16). As for postoperative care, videoconferencing and digital cameras provided an accurate diagnosis and treatment plan.

One general limitation to the implementation of telemedicine technology has been noted. The development of this technology is not yet accessible to all hospitals for several reasons. First, the direct cost savings of telemedicine are still not significant for the healthcare system (36). Among the 24 studies reviewed, one reported that the cost of purchasing software and digital cameras to link desktop computers and transmitting live video in neonatal surgical consultations was between 5000-15,000 U.S. dollars (9). According to Wallace et al., there was no evidence of cost savings with telemedicine (20). Furthermore, healthcare providers need to be educated and trained on the use of telemedicine to apply it effectively. Our study shows telemedicine to have more advantages over traditional surgical care. Therefore, we suggest that healthcare providers implement telemedicine technologies in hospitals to support healthcare providers to deliver more efficient care. In terms of further research, we recommend conducting a randomized controlled trial or group trial because they

provide more robust evidence than observational studies. As most of the studies included in our review used older and current technologies, up-to-date studies, looking at the new generation of technologies that will have an impact on how surgical care is practiced.

Implications for practice

This systematic review reports on the broad range of telemedicine technology use in surgical care. Telemedicine has potential benefits for surgical care in terms of providing improved efficiency and quality of care. It can improve healthcare access for a much larger patient population and decrease hospital readmissions. However, several challenges are associated with the development of telemedicine for surgeons. First, telemedicine requires different clinical skills, so surgeons should be educated on how to use telemedicine effectively. Moreover, surgeons must take into account patient privacy, which is a significant concern for the implementation of telemedicine. One of the current solutions is to use advanced encryption security protocols and standard, which can protect the privacy and confidentiality of patient information (15). Regardless of the challenges, telemedicine may result in fundamental changes in surgical practice.

5. CONCLUSION

Our study finds that telemedicine in surgical care can provide benefits to both patients and healthcare providers. Telemedicine can improve patient access to the healthcare system and provide significant time savings to both patients and healthcare providers. In addition, telemedicine can play an important role in improving care through the collaboration of surgical teams located at different sites. It is important to note that additional efforts are needed to overcome the barriers to implementing telemedicine technology in surgical care.

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- **Conflict of interest:** none declared.

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