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Review Article

Emerging role of telemedicine in perioperative anaesthesia and pain management

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ABSTRACT

The novel coronavirus disease (COVID-19) pandemic has caused significant alterations in our traditional healthcare system. The use of technologies such as telemedicine has seen a rapid upsurge. Though the benefits of telemedicine are well-documented; its use in anaesthesia is still in the nascent stage. Various authors have successfully demonstrated its application in perioperative anaesthesia and chronic pain. The ongoing pandemic has highlighted the importance of its more widespread use in anaesthesia. The establishment of clear guidelines addressing telemedicine and its legal and ethical concerns by many countries should provide a further impetus to its more frequent adoption. This article aims to review the existing literature about the use of telemedicine in the preoperative, intraoperative and postoperative phases of anaesthesia as well as in chronic pain and academics. As the pandemic abates, it presents a unique opportunity to expand the application of telemedicine in the various spheres of anaesthesia and pain.

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1. Introduction

Since the detection of the first case of the novel coronavirus diseases (COVID-19) in 2019 in Wuhan, China; the infection has spread at an alarming pace throughout the world.^{1–4} The rising cases have created unprecedented challenges for the healthcare systems. With the disease reaching the pandemic stage, countries all over the world are facing acute shortage of healthcare staff, health resources such as ventilators, personal protective equipment, facemasks etc.^{5–9} Since the infection is spread by person-to-person transmission, control measures including social distancing, stay-at-home guidelines, contact tracing, early self-isolation and quarantine, travel restrictions, prohibition of mass gatherings etc. are being adopted.^{10–15} Additionally, it is also imperative that diligent

efforts be made to ensure that people suffering from other medical or surgical ailments are not deprived of their healthcare needs.

In such a scenario, utilization of existing technologies such as telemedicine is playing a very important role. Virtual healthcare delivery is being scaled up and integrated into the current healthcare system. Virtual care can reduce the burden on the hospitals and healthcare system while simultaneously protecting healthcare workers as well as patients from exposure to the novel coronavirus.^{16–18} This review aims at understanding telemedicine and its various benefits and disadvantages with special emphasis on the emerging scope of telemedicine in perioperative anaesthesia and chronic pain.

This review is being written with an objective to summarize the existing literature related to the applications of telemedicine in perioperative anaesthesia, chronic pain and academic training. The literature search was done

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from various search engines including PubMed, Cochrane Library, and Google Scholar. The search words included “telemedicine”, “telehealth” “telemedicine advantages”, “barriers telemedicine”, “telemedicine history”, “telemedicine Covid-19”, “telemedicine coronavirus”, “telemedicine India”, “telemedicine MCI guidelines”, “teleanaesthesia”, “tele-pain”, “telemedicine anaesthesia”, “telemedicine preoperative”, “telemedicine intraoperative”, “telemedicine postoperative”, “telemedicine chronic pain”, “teleanaesthesia training”, and “teleanaesthesia education”.

The published literature related to application of telemedicine in anaesthesia has been included and all study designs including systematic reviews and editorials were studied. During the search, any published literature not related to telemedicine were excluded. The literature published till December 2020 were included in this review.

2. What is Telemedicine?

Literally meaning ‘medicine at a distance’, the term telemedicine was first used in the 1970s and since then has seen multiple definitions by various authors.^{19,20} This itself underscores the fact the technology of telemedicine is in a constant state of flux with continual advancements.

World Health Organization (WHO) has defined telemedicine as “The delivery of health care services, where distance is a critical factor, by all health care professionals using information and communication technologies for the exchange of valid information for diagnosis, treatment and prevention of disease and injuries, research and evaluation, and for the continuing education of health care providers, all in the interests of advancing the health of individuals and their communities”²¹ Recently, the Medical Council of India (MCI) adopted the same definition in its Telemedicine Practice Guidelines published in March 2020.²² The role includes online consultations with specialists via telephone or videoconference, telemonitoring patients’ health parameters and transmitting them to their healthcare departments, and tele-learning and training of healthcare workers and /or patients, etc.

2.1. Types of telemedicine

Telemedicine can be classified into two main types depending on the timing of transmitting information- synchronous and asynchronous. Synchronous telemedicine employs real-time communication between patient and healthcare provider via video, audio or text. Asynchronous (store-and-forward) telemedicine involves relaying of health-related data via images, videos, texts, e-mails etc. which can then be evaluated at a later time.^{22,23}

2.2. Advantages of telemedicine

Digital healthcare has offered numerous benefits to patients as well as healthcare professionals even in the pre-COVID

times.^{24–27}

1. Improves access of healthcare, especially specialist services, in rural or otherwise remote areas.
2. Provides better availability of medical care to disabled, elderly, or those with dearth of adequate transportation facilities
3. Decreases travel time and costs, and thereby healthcare costs for patients
4. More environmental-friendly due to reduced travel-related emission of pollutants.
5. Increases patient convenience; decreases time spent waiting for appointment.
6. Helps in tele-monitoring of patients’ health at home.
7. Facilitates consultations between healthcare workers present at different locations.
8. Tool for e-learning and education for medical professionals; especially those located in remote areas.

Studies have shown improved or similar outcomes when patient suffering from chronic ailments such as diabetes mellitus or hypertension received medical care via telemedicine.^{26,28} The unique constraints during the COVID-19 pandemic have provided a new impetus to telemedicine. Healthcare providers worldwide are scrambling to adopt virtual healthcare and incorporate it into their patient care routines.^{18,29} In addition to lessening the risk of exposure for healthcare workers and patients, it can also enable more efficient screening and triage of patients before admission to hospitals.^{23,30–33} Telemedicine can also help provide medical care to patients suffering from other chronic diseases in the convenience of their homes without having to potentially get exposed to the infectious virus.¹⁷

2.3. Barriers to telemedicine

Despite all its benefits, the technology of telemedicine is not without limitations:

1. Absence of physical examination leading to missing out on important clinical information.³¹
2. Certain diagnoses and treatments may not be possible without face-to-face examination.³¹
3. Perception of virtual care as being impersonal and remote by patients.^{24,34,35}
4. Lack of knowledge about telemedicine and dearth of access to good internet connectivity; especially for the elderly, illiterate or those living in the rural areas.^{24,34,35}
5. Resistance from physicians and/or patients for adoption of new or unfamiliar technology.^{24,27,36}
6. High initial cost of investment and lack of reimbursement for virtual care.^{27,36}
7. Maintenance of confidentiality and security of personal medical data and the susceptibility of digital health for cybercrime.^{36–38}

8. Lack of clear and specific guidelines in majority of the countries regarding the use of telemedicine and its legal and ethical concerns, especially before the advent of COVID19.^{24,27}

3. Telemedicine in India

Though the technology of telemedicine is not new to India, it has not been utilized to its maximum potential in India. However, because of its many benefits, telemedicine can prove to be an invaluable tool for healthcare in a populous country like India with a diverse topography. Moreover, it can also help in making both specialised and routine healthcare more accessible to the vast population residing in rural areas.^{22,39}

Initial initiative for telemedicine in India was taken by the Indian Space Research Organization (ISRO) in 2001 via a Telemedicine Pilot Project connecting Apollo Hospital at Chennai to the Apollo Rural Hospital at a village in Andhra Pradesh. Since then, ISRO has been expanding its telemedicine network each year.⁴⁰ Other government organizations such as Ministry of Health and Family Welfare and Department of Information Technology as well as leading technical and medical establishments have also been contributing to virtual healthcare delivery in India.^{17,24,39,41} Nonetheless, the use of telemedicine was still being approached warily by the healthcare workers. In addition to the other barriers, the absence of well-defined guidelines has acted as a significant deterrent for physicians to adopt telemedicine into their routine practice. However, taking into consideration the present COVID-19 pandemic and its distinctive precautions; the Medical Council of India (MCI) brought forward its Telemedicine Practice Guidelines in corroboration with NITI Aayog. These are meant to allow Registered Medical Practitioners (RMPs) to deliver healthcare via telemedicine. It is hoped that with the support of these guidelines, digital health will be adopted by more and more medical professionals in the future.²²

4. Scope of Telemedicine in Anaesthesia

The field of medicine must continuously embrace the novel technological advancements and innovations in order to keep up with the ever-changing world. Applications of telemedicine have been explored by various medical specialities such as dermatology,⁴² neurosurgery,⁴³ neurology,^{44,45} radiology^{46,47} etc. Though various authors have reported the use of telemedicine in anaesthesia, however, it is still not widespread (Table 1).

The galloping advances in information and communications technology and access of internet services, even in remote areas, are increasing the possibilities and applications of telemedicine in anaesthesia. The COVID-19 pandemic has further given its use and acceptance a forcible push in the various phases of anaesthesia care (Figure 1).

5. Preoperative Applications

Various authors have discussed and described the use of telemedicine for remotely conducting a pre-anaesthetic check-up. Ansary et al have described possible methods of a virtual physical examination. Apart from routine equipment such as blood pressure monitors and glucometers, newer technologies such as electronic stethoscopes, smartphone applications, wearable sensors etc. can aid the remote physical examination.⁴⁸ This can very well be incorporated into the physical examination needed for PAC.

A tele-PAC is economical with respect to both time and money with high patient and provider satisfaction (Figure 2). It has not been seen to cause any unnecessary cancellation or delays in surgery. Tele-PAC can be especially viable for geriatric patients by decreasing the inconvenience of travel. However, the associated comorbidities, airway challenges etc. in the elderly population may, in fact, necessitate an in-person PAC. A virtual PAC can also be utilized to educate the patient regarding the procedure and risks of anaesthesia using videos.⁴⁹

Another possible application of telemedicine, which has not been explored widely, is virtual prehabilitation before surgery. Telemedicine can be used to educate patients about their individualized needs to increase their functional capacity and optimize their preoperative status. Smoking cessation, breathing exercises etc. can be explained and demonstrated. Remote spirometry can also be explored. A telespirometric system has been described by Nowinski et al in 2015.⁵⁰ Patients' preoperative medications, diet and fluid status, weight, glucose levels etc. can be monitored and optimized. These can help to prepare the patient for surgery in a better way and possibly improve the postoperative outcome.

6. Intraoperative Application

A handful case reports have described the use of telemedicine for remote anaesthetic monitoring and even remote drug delivery. It can help expand the reach of anaesthesiologists to remote areas for more complex procedures. However, intraoperative use of tele-anaesthesia faces significant challenges. A high-speed internet connection with a good bandwidth without any disruption in transmission is a minimum requirement. The transmission should involve not just the vital monitors but also the live video telecast of the surgical field so as to better guide the anaesthetic management. Though the availability of these services is increasing even in remote areas, but maximum caution needs to be taken as any interruption in transmission can prove to be disastrous for the patient.

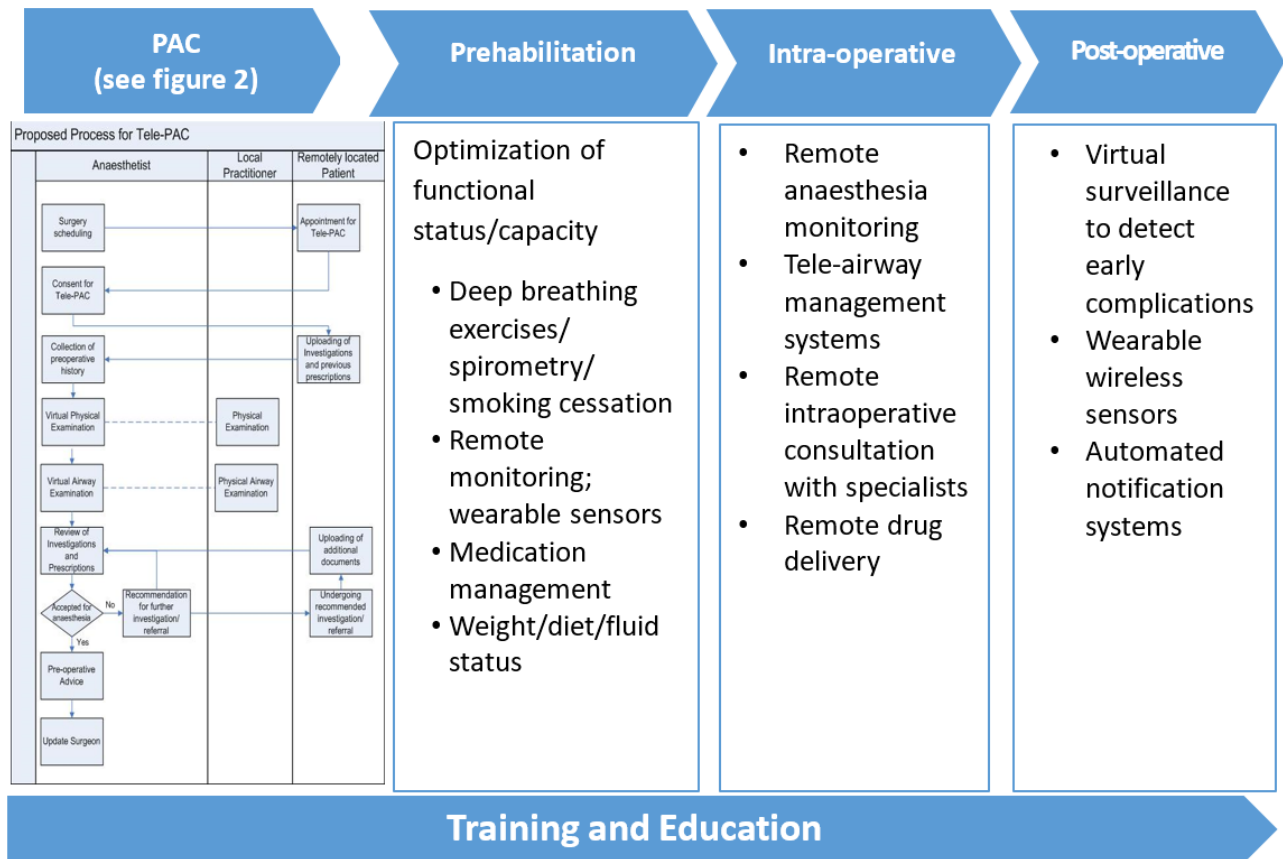


Fig. 1: Integration of telemedicine in perioperative care

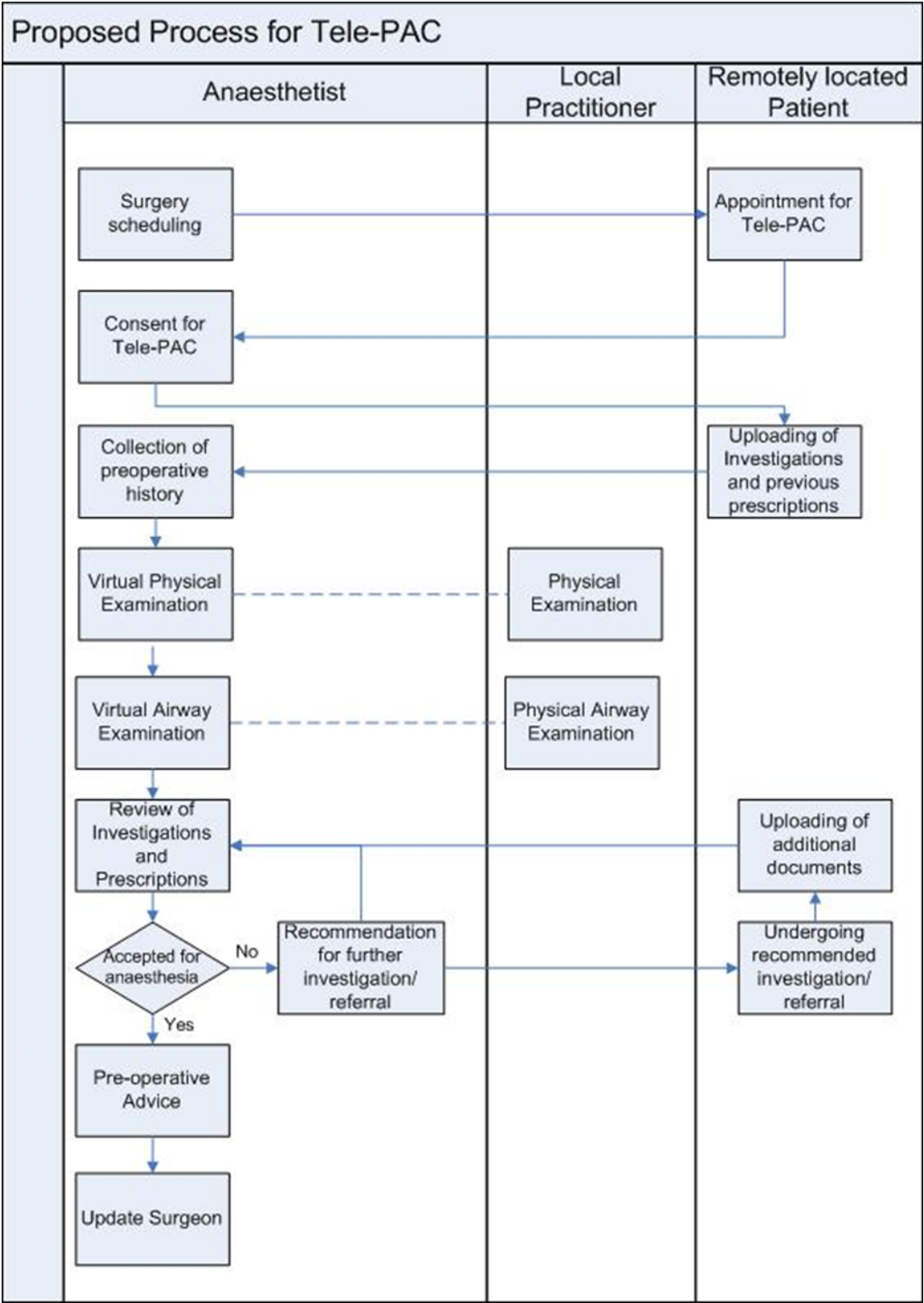


Fig. 2: Proposed process of Tele-PAC

Table 1: Shows the various studies related to the application of telemedicine in anaesthesia and pain medicine

Reference	Study Type	Objective	Sample Population	Results
Preoperative Applegate et al (2013) ⁵¹ (48)	Prospective randomized trial	To compare telemedicine pre-anaesthetic check-up (PAC) with face-to-face PAC on perioperative processes	160 adult patients slated for head and neck surgery	Telemedicine and in-person PAC found to be comparable with high patient and doctor satisfaction with both methods
Boedeker et al (2007) ⁵²	Prospective questionnaire based survey	To assess patient perception for virtual PAC clinic	13 patients scheduled for elective surgery	Demonstrated patient preference for tele-PAC
Brull et al(2006) ⁵³	Randomized controlled trial	To evaluate patient satisfaction with a preadmission tele-consent on day of minimal-risk surgery	124 patients scheduled for arthroscopic shoulder surgery	Tele-consent did not improve patient satisfaction
Dilisio et al (2014) ⁵⁴	Case report	To present a case of virtual preoperative airway examination to gauge viability of office-based anaesthesia	An adult patient scheduled for dental extraction	Airway examination using telemedicine can offer important information about achievability of office-based anaesthesia
Kamdar et al (2020) ⁵⁵	Retrospective non-randomized descriptive study	To study implementation of PAC via telemedicine	2204 patients scheduled for elective surgery	High patient satisfaction, more cost-friendliness, and no increase in case cancellation rate with virtual PAC
Karim(2020) ⁵⁶	Correspondence	To describe cloud-computing based virtual PAC	-	Possible benefit to patients but has various limitations
Lozada et al(2016) ⁵⁷	Prospective survey	To evaluate patient satisfaction with PAC via telephone	75 postoperative patients	Patient preference for Tele-PAC with no rise in case cancellations
Mullen-Fortino et al (2017) ⁵⁸	Retrospective data review	To determine effect of telemedicine on presurgical assessment	7803 patients scheduled for elective surgery	Better patient satisfaction, decreased time for PAC, no increase in surgical cancellation rate
Rogers(2020) ⁵⁹	Non-randomized pilot study and evidence based project	To employ telemedicine for paediatric PAC and assess patient and provider satisfaction	14 patients and 6 nurse practitioners	High patient and provider satisfaction with Tele-PAC
Srivastava et al (2020) ⁶⁰	Correspondence to editor	To highlight the importance and practical application of Tele-PAC during Covid-19 pandemic	-	Encouraging alternative to in-person PAC

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Table 1 continued

Wong et al (2004) ⁶¹	Pilot study	To study feasibility of PAC via telemedicine	10 patients scheduled for elective surgery	Successful use of telemedicine for PAC with high patient and anaesthesiologist satisfaction
Intraoperative				
Cho (2011) ⁶²	Pilot study	To evaluate utility of Tele-Airway Management System (TAMS) for intubation of patients in emergency	25 patients with inability to maintain airway	Comparable result of TAMS with in-person intubation in terms of time for intubation and success rate
Chung et al (2007) ⁶³	Randomized controlled trial	To compare efficacy of TAMS vs video-laryngoscope alone for emergency intubation	33 trainee intubators (medical students and interns)	Better success rate with TAMS with lesser time for intubation
Cone et al (2004) ⁶⁴	Case report	Description of use of telemedicine for remote monitoring of anaesthesia	Adult female scheduled for cholecystectomy	Demonstrated successful use of remote intraoperative monitoring
Cone et al (2006) ⁶⁵		Description of use of telemedicine for PAC and intraoperative anaesthetic monitoring using satellite communication	5 patients posted for elective surgery under general anaesthesia (GA) and 2 under spinal anaesthesia (SAB)	Successful description of teleanaesthesia for preoperative discussion and intraoperative monitoring
Fiadjoe et al (2009) ⁶⁶	Case reports	Description of telemedicine use to assist living related paediatric liver transplants	Two paediatric patients planned for elective liver related liver transplant	First report of successful use of remote anaesthesia for preoperative and intraoperative consultation for organ transplantation
Hemmerling et al (2013) ⁶⁷	Prospective pilot study	To assess feasibility of transcontinental remote anaesthesia	20 patients undergoing elective thyroid surgery	Demonstrated good hypnosis and analgesia with remotely controlled total intravenous anaesthesia
Ihmsen et al (2007) ⁶⁸	Prospective pilot study	To evaluate viability of a remote EEG-controlled closed-loop propofol administration intraoperatively	11 patients undergoing surgery under GA	Successful demonstration of teletherapeutic administration of propofol for GA
Miyashita et al (2015) ⁶⁹	Prospective pilot study	To determine correlation between transmission bandwidth and delay time in tele-anaesthesia system	25 patients undergoing minor surgery under GA	Decrease in delay time and increase in frame rate achieved with a higher bandwidth in tele-anaesthesia system
Postanaesthesia care unit (PACU)				

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Table 1 continued

Blankush et al (2016) ⁷⁰	Prospective observational study	To determine if postoperative monitoring with automated notification techniques can identify patients at risk for deterioration	133 postoperative patients	Automated notification systems can be used in postoperative patients but need further studies
Boer et al (2018) ⁷¹	Narrative review	To summarize concept of remote vitals monitoring in PACU and review its existing evidence	-	Remote vitals monitoring in PACU may prevent severe postoperative complications
Breteler et al (2018) ⁷²	Observational study	To determine reliability of wireless wearable sensor for remote monitoring in high-risk postoperative patients	25 postoperative patients	Accurate measurement of heart rate (HR) but not of respiratory rate (RR) by the wireless sensor
Downey et al (2019) ⁷³	Randomized controlled parallel group trial	To validate accuracy of wearable remote sensor for monitoring vitals in high risk postoperative patients	51 postoperative patients after major elective surgery	Discrepancies in HR measurements and low correlation in RR measurements
Posthuma et al (2019) ⁷⁴	Prospective observational study	To evaluate feasibility of continuous wireless RR monitoring in postoperative patients	126 patients undergoing moderate and major general surgery	Reliable measurement of RR upto 4 days postoperatively
Perioperative				
Bridges et al (2020) ⁷⁵	Narrative review	To review literature pertaining telemedicine in preoperative, intraoperative and postoperative phases of anaesthesia	-	Telemedicine in anaesthesia is novel but rapidly evolving. However, it has limitations and needs further research
Galvez et al (2011) ⁷⁶	Narrative review	To review applications of telemedicine in anaesthesia	-	Telemedicine in anaesthesia shows promise
Chronic Pain				
Burton et al (2000) ⁷⁷	Descriptive study	To describe the operation of a telepain clinic	280 patients suffering from chronic pain	More time-efficient for physicians
Byrne et al (2020) ⁷⁸	Survey	To study experience of patients using telepain service	66 patients	Positive patient perception (decreased travel time, better access to care)
Dario et al (2017) ⁷⁹	Systematic review with meta-analysis	To assess if telehealth services decrease pain and disability in non-specific low back pain	11 studies	Limited benefit demonstrated
Emerick et al (2020) ⁸⁰	Commentary	To discuss expert opinion regarding use of telemedicine in chronic pain	-	Considerable benefits of telepain services which warrant use beyond Covid-19 pandemic

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<i>Table 1 continued</i>				
Ghai et al (2020) ⁸¹	Special article	To describe use of telemedicine for chronic pain management during Covid-19 pandemic	-	Telemedicine can be used for pain management even beyond the period of Covid-19
Li et al (2020) ⁸²	Editorial	To discuss the use of telehealth for chronic pain management during Covid-19 pandemic	-	Digital health can be applied to chronic pain management but limitations need to be considered
Mariano et al (2019) ⁸³	Systematic review	To assess advantages of telemedicine in chronic pain management	12 studies	Teletherapy can be effective for chronic pain management but further controlled trials are needed
Peng et al (2006) ⁸⁴	Prospective pilot study	To evaluate feasibility, cost-benefit and patient/provider satisfaction for chronic pain consultation	11 telemedicine follow-up consultations involving 8 patients	Follow-up consultations found to be feasible and economical with high patient and provider satisfaction
Provonost et al (2009) ⁸⁵	Randomized crossover trial	To determine cost-effectiveness of telemedicine for chronic pain management	26 patients	Cost-effectiveness of telemedicine is more than in-person consultations
Training and education				
Eaton et al (2018) ⁸⁶	Cluster randomized controlled trial	To assess effect of telementoring on knowledge and competence in chronic pain management	41 primary care providers	No increase in knowledge and perceived competence; further research needed
Furlan et al (2019) ⁸⁷	Pre-post online survey	To study impact of tele-education on knowledge, self-efficacy and satisfaction of physicians	296 primary healthcare providers	Better knowledge and self-efficacy with tele-education programme
Laurent et al (2016) ⁸⁸		To discuss feasibility of telesimulation for teaching ultrasound guided regional anaesthesia (UGRA)	19 anaesthetists	Successful demonstration of remote telesimulation-based training for UGRA

7. Postoperative Application

In the immediate postoperative period, telemedicine can be used for remote monitoring of vital parameters. Intermittent monitoring can cause oversight of early signs of deterioration; whereas continuous monitoring of vital signs can help detect these changes in the physiological parameters of patients in the PACU. The use of remote monitoring devices and automated notification systems which continually give information to the attending anaesthetist can facilitate early identification and timely treatment of any derangement in these parameters. However, further research and studies are needed to develop reliable and cost-effective systems for such virtual surveillance.

8. Application in Chronic Pain

Telemedicine can be a valuable alternative for management of chronic pain. Patients with chronic pain are often of old age, have other comorbidities and may have mobility issues. Therefore, virtual therapy can be more convenient for them. Physicians also can get a better understanding of the patients' mental status and social factors in their home which can help in better adjustment of their management. Prescribing medicines, especially in a follow-up consultation which usually only requires titration, can be done conveniently via telemedicine. In addition, non-pharmacological modalities such as posture adjustment, exercise, lifestyle modification etc. constitute an important part of the treatment of chronic pain. These can be easily communicated and evaluated via virtual therapy.

9. Training and Academics

Training and education using telemedicine; also known as telementoring; can help bridge the divide between premiere medical institutions and remote places with inadequate access to specialists. Training and consultations can be provided to students and primary care providers living in geographically distant places. In the field of anaesthesia, telementoring has been described for chronic pain management and UGRA. However, further studies are needed for better implementation of such programmes on a wider scale to cover other aspects of anaesthesiology as well.

10. Conclusion

Any large-scale crisis, such as a war or pandemic, leads to unprecedented efforts from government organizations for medical research; often leading to a spurt in medical and surgical innovations.⁸⁹ The Covid-19 pandemic has also created a huge upheaval in the healthcare system with more focus being placed on Covid-19 and its related research and a wider acceptance of telemedicine. The benefits of telemedicine are well-documented. The ongoing pandemic has offered a special opportunity to expand the utilization of

virtual health systems in anaesthesia. The learnings during this experience can very well be extended into use during the post-pandemic period also. After this health crisis abates, it will be interesting to see how the healthcare system overall and the field of anaesthesia in particular resurfaces and reforms itself. But going by the present acceptance of telemedicine by both patients and providers in various fields, virtual health seems to be here to stay.

However, before its use becomes more universally accepted in the realms of anaesthesiology even beyond the period of the pandemic, more controlled studies and research needs to be done so as to better refine its applications in anaesthesia.

11. Declaration of Conflicting interests

The authors declare that there is no conflict of interest
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12. Authorship

All authors contributed to the study conception and design. Material preparation, data collection and analysis were performed by Dr Kritika Agrawal and Dr Satyajit Majhi. The first draft of the manuscript was written by Dr Kritika Agrawal and all authors commented on previous versions of the manuscript. All authors read and approved the final manuscript.

13. Compliance with Ethics Guidelines

This article is based on previously conducted studies and does not contain any new studies with human participants or animals performed by any of the authors.

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