Original Articles

Safety and efficacy of axillary block for emergency upper limb orthopaedic interventions, where there is no anaesthesiologist

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ABSTRACT

Background. Surgical healthcare across low- and middle-income countries is plagued with concerns over scarcity of anaesthesiologists. Orthopaedic surgeons working in such resource-limited settings are often caught in a dilemma to provide emergency orthopaedic surgical care without an attending anaesthesiologist. Therefore, an effective, low-risk solution is necessary to ensure safe emergency orthopaedic care.

Methods. We evaluated the incidence of 'anaesthesia-related complications' and 'intraoperative adjuvant medications' for maintenance of adequate anaesthesia for patients who underwent emergency upper limb procedures at a remote mission hospital in rural central India, from June 2013 to June 2016. Emergency cases where there was no anaesthesio-logist were analyzed. Data were collected from the Hospaa 3 HMS software, orthopaedic surgical logbook and inpatient records from 2013 to 2016.

Results. Sixty-eight patients underwent an 'axillary block' for emergency orthopaedic procedures. Twelve (17.6%) patients had partial block and needed adjuvant medications, 1 (1.4%) patient developed ulnar nerve palsy with partial recovery. Seventy-six adjuvant medications were administered at a mean of 1.19 per patient during the intraoperative period.

Conclusions. Axillary regional block is an efficacious, low-risk anaesthesia for emergency orthopaedic procedures of the hand, forearm and elbow, in resource-limited settings where an anaesthesiologist is not available.

Natl Med J India 2020;33:69–73

INTRODUCTION

Lopsided distribution of healthcare resources and growing demand from stakeholders in India's rural healthcare sector has long been the driving force for medical teaching institutions to send out their trainees and alumnus to sustain and support healthcare in remote areas across the country. The mandatory service obligation for medical graduates and postgraduates has withstood the test of time and has ensured minimal credible healthcare even in the remotest parts of the country.[1–3] Declining poverty rates, government-sponsored health insurance schemes, increasing literacy rates, awareness and healthcare-seeking behaviour of the general population and enforcement of healthcare laws have emphasized on the quality-oriented, specialty-driven approach in the current healthcare scenario.[4–6] Therefore, the old adage, 'jack of all trades, master of none' is losing credibility as well as legality.[7,8] The skewed human resource policy of a 'person-specific approach' as opposed to a 'team-specific approach' has resulted in deficiency in surgical teams in remote hospitals with limited or no access to anaesthesiologists.[9] Hence, orthopaedic surgeons working in remote areas often do not have an anaesthesiologist in the surgical team, and are unable to ensure safe and optimum surgical care for their patients. We evaluated the risk and efficacy of alternative anaesthesia such as a regional axillary block (AB) for emergency operations of the hand, forearm and elbow that were done in such situations.

Historically, regional anaesthesia has proved to have lower rates of complications, but minimal evidence exists regarding regional anaesthesia when administered by 'non-anaesthetists'. We assessed the perioperative 'anaesthesia-related complications' and 'intraoperative adjuvant medications' used during regional AB for emergency orthopaedic procedures of the upper limb, when there was no anaesthesiologist in a resource-limited set-up in central India.

METHODS

Demographic data of all patients who underwent emergency orthopaedic procedures of the hand, forearm and elbow at the remote mission hospital over a period of 3 years, from July 2013 to June 2016 were collected from the Hospaa 3 HMS software, orthopaedic surgical logbook and inpatient charts. Children under 15 years of age, adults who underwent elective surgery of the hand, forearm and elbow under general anaesthesia (GA) with an attending anaesthesiologist, patients who underwent surgery of the shoulder and upper arm, patients with incomplete perioperative records and patients with medical comorbid conditions were excluded from the study. Informed consent for emergency surgery and anaesthesia was obtained before all emergency procedures. When the attending anaesthesiologist

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TABLE I. Anaesthesia protocol for emergency upper limb orthopaedic procedures

Preoperative	Intraoperative	Postoperative
• History and physical, clinical and radiological assessment by the surgeon • CBC, BBVS and blood group • Additional tests for patients with co-morbid conditions or >40 years of age	• Administration of axillary block by a 'non-anaesthetist' (surgeon/nurse) • Administration of 'intraoperative adjuvant medications' as per surgeon's order	• Transferred from operating room to recovery after patient optimization
• Risk assessment and decision-making: Local care versus referral • Availability or non-availability of an anaesthesiologist • Documentation by the surgeon	• Monitored by an ANM/GNM nurse • Documentation of vital parameters and 'intraoperative adjuvant medications'	• Monitored by an ANM/GNM nurse • Documentation of vital parameters and medications
• Remote pre-anaesthetic consultation	• Monitoring with pulse-oximeter, automatic blood pressure cuff and ECG leads	• Monitoring with pulse-oximeter, automatic blood pressure cuff and ECG leads
• Written informed consent	• Airway management and management of any complications as per surgeon's instructions	• Airway management and management of any complications as per surgeon's instructions
• Pain management with i.m. opiates, NSAIDs	• Pain management with i.m./i.v. opiates, i.m./i.v. NSAIDs	• Pain management with i.m./i.v. opiates, i.m./i.v. NSAIDs
• Laboratory work-up and assessment of need for whole blood	• Decision for transfusion by surgeon	• Transfusion based on postoperative blood work-up

CBC complete blood count BBVS blood-borne viral serology ANM auxiliary nurse-midwife GNM general nurse-midwife AYUSH ayurveda, yoga and naturopathy, unani, siddha and homoeopathy ECG electrocardiogram NSAIDs non-steroidal anti-inflammatory drugs

was not available, patients were given prior information and option for referral to a higher centre was explained and documented in all cases.

Detailed preoperative history and physical examination were documented for each patient by the first author. Any coexisting morbidity was identified. Routine investigations including complete blood counts and blood-borne viral screening were carried out for each patient. Those with coexisting morbidity or over 40 years of age underwent additional investigations such as blood sugar level, chest X-rays and electrocardiography. The remote pre-anaesthetic consultation was carried out with the second author. AB was administered by the primary author. Members of the surgical team had certified training in basic life support and early management of trauma. A protocol for the administration of AB was drawn up through remote consultation with anaesthesiologists, who had prior experience and understanding of the resource limitations at the said centre (Tables I and II).

A cocktail of 0.25% bupivacaine or 0.75% ropivacaine (10 ml) and 2% lidocaine (10 ml) with 1:200 000 epinephrine was used for AB (Table II). The palpatory manual method was used to administer AB. The technique was learned and adopted through hands-on training, telephonic conversation and remote instructions, online video demonstrations and android communication app-assisted instructions from the anaesthesiologist. All patients were pre-medicated with intramuscular pentazocine and intravenous ondansetron. AB was routinely augmented with intravenous midazolam 0.1 mg/kg. Perioperative monitoring was conducted by diploma-trained nurses as per the anaesthesia protocol (Table I).

The incidence of 'anaesthesia-related complications' and number of 'intraoperative adjuvant medications' were used as parameters for risk assessment and efficacy assessment, respectively. Perioperative adverse events associated with administration, intraoperative relaxation and recovery from anaesthesia were defined as 'anaesthesia-related complications'. Surgical complications were not included in this study. 'Anaesthesia-related complications' managed by the surgical team were identified and tabulated using Microsoft Excel 2007 software. AB-related complications included ulnar nerve injury, partial block, need for augmentation with sedatives, tourniquet pain, need for repeat block and delayed recovery.[10–15]

Average incidence of 'anaesthesia-related complications' associated with AB administered by a 'non-anaesthetist' and the average number of 'intraoperative adjuvant medications' were calculated.

RESULTS

A total of 213 patients underwent orthopaedic upper limb surgical procedures between July 2013 and June 2016. We excluded 145 patients from this study due to pre-existing comorbid conditions, age <15 years or when the attending anaesthesiologist was available. Sixty-eight patients who underwent emergency operations of the hand, forearm and

TABLE II. Axillary block protocol for emergency orthopaedic procedures of upper limb (palpatory method)

Pre-medication
Pentazocine (30 mg intramuscular)
Ondansetron (8 mg intravenous)
Cocktail of
Bupivacaine (*n*=62) or ropivacaine (*n*=2) (10 ml) with 2% lidocaine (10 ml) with 1:200 000 epinephrine (*n*=64)
Additional 1% lidocaine used for local infiltration in case of partial block and for anterior brachial nerve block
Midazolam (0.1 mg/kg intravenous)
Diazepam (0.1 mg/kg intramuscular)
Ketamine (1–2 mg/kg intravenous)
Palpatory manual method was used to administer axillary block

elbow under AB administered by a 'non-anaesthetist' were included in the study.

Ten patients underwent major debridement, 24 patients needed orthofix/universal monolateral external fixator-assisted ligamentotaxis and closed reduction and internal fixation of distal radius intra-articular fractures, 9 patients had debridement, open reduction and internal fixation for forearm both bones fractures, 15 patients underwent minor debridement, 4 patients underwent closed reduction, 1 patient had urgent fasciotomy and 1 patient underwent multiple tendon and vascular repair.

Thirteen (19.1%) patients who underwent emergency orthopaedic upper limb surgical procedures under AB administered by a 'non-anaesthetist' had perioperative 'anaesthesia-related complications' (Fig. 1). Twelve (17.6%) patients had a partial block (7) or tourniquet pain (5) and required additional medication. Among them, repeat AB was administered to 2 patients; additional wrist block or metacarpal block was administered to 3 patients and intramuscular pentazocine was administered to 7 patients. Three patients required intravenous ketamine to complete the procedure. One (1.4%) patient developed ulnar nerve palsy with partial recovery at 6-months of follow-up.

Seventy-six adjuvant doses of medications were administered at a mean of 1.19 per patient during the intraoperative period (Fig. 1). Thirty-six additional doses of 2% lidocaine, 7 doses of ketamine, 5 doses of midazolam, 16 doses of diazepam, 7 doses of pantoprazole, 4 doses of ranitidine, 4 doses of diclofenac and 1 additional dose of bupivacaine were administered to patients undergoing emergency operations of the hand, forearm and elbow under AB administered by a 'non-anaesthetist'. These medications were administered over and above the initial anaesthetic dose as per the 'anaesthesia protocol'.

DISCUSSION

An operating team lacking an anaesthesiologist is the quintessential saga of low- and middle-income countries (LMICs) urban–rural healthcare gap.[16] With only 1 anaesthesiologist available for a 100 000 population and concentration of anaesthesiologists in urban centres, an overwhelming majority of patients in rural areas do not have access to safe and cost-effective anaesthesia and surgical care.[17–19] Attempts to overcome this gap, bogged down by scepticism and short-sighted policies, are yet to show results.[9,17,20,21] This has led to a skewed ratio of 'surplus surgeons' and 'absent anaesthesiologist' in the rural healthcare sector.[18,22,23]

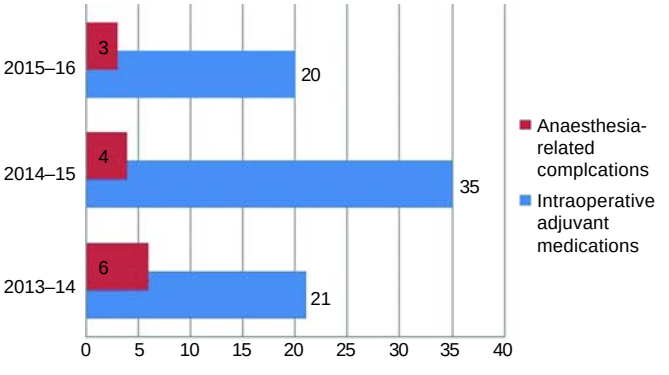

FIG 1. Annual incidence of complications and intraoperative adjuvant medications associated with axillary block (2013–2016)

Healthcare institutions in remote locations have a severe shortage of physician anaesthesiologist and are often compelled to function without a full-time anaesthesiologist, or at most can boast of part-time volunteers.[9,24–26] With limited qualified 'hands on deck' during an operation, immense pressure is exerted on the surgical team and the surgeon to anaesthetise, monitor and manage 'anaesthesia-related' complications while at the same time perform the operative procedure. Limited medical support system and inaccessibility to expert help in the rural set-up make this a 'pressure cooker situation'. Thus, increasing the risk of intraoperative error and compromising the quality of anaesthesia as well as surgical outcome. Healthcare pioneers having anticipated this crisis have initiated novel solutions by training and employing 'non-anaesthetists' encompassing a wide spectrum of available cadre.[27,28] Of course, the detractors have unceremoniously dismissed this practice citing risk associated with a 'non-anaesthetist' administering anaesthesia despite no evidence to the contrary.[29] However, in the absence of an alternative, 'non-anaesthetists' are managing the bulk of essential surgical care of patients in several remote areas.[7] Healthcare regulatory bodies and current healthcare guidelines and laws do not have any provision for 'non-anaesthetists' and no standardized course structures exist. However, questions regarding risk and efficacy of anaesthesia administered or supervised by 'non-anaesthetists' must be assessed, investigated and audited. Surgeons working in areas of need and remote locations are pushed to find a solution to overcome this 'devil and the deep sea' situation where he/she must provide essential surgical care despite having no anaesthesiologist.

However, there is no immediate solution to this dilemma. This study attempts to assess the safety and effectiveness of an alternative option when there is no anaesthesiologist. In a resource-limited setting, where a qualified anaesthesiologist is absent, regional anaesthesia has proven safer than and as effective as GA.[30–32] However, regional anaesthesia is not devoid of complications; it often requires training and has a variable learning curve and limited applications. Hence, to investigate and identify an efficacious, low-risk anaesthesia option for conducting emergency operations of the upper limb (hand, forearm and elbow) in a mission hospital in a remote location, we assessed the 'anaesthesia-related complications' rate and need for 'intraoperative adjuvant medications' associated with AB administered by 'non-anaesthetists'. The role of spinal and intravenous administration of anaesthetic agents by a 'non-anaesthetist' is documented only in emergency obstetric care. We could not find any evidence in the literature to compare risk associated with the use of regional anaesthesia for upper limb emergency orthopaedic procedures without an attending anaesthesiologist.[29–31] We looked at the efficacy of anaesthesia from the surgeon's perspective. Adequate anaesthesia during the intraoperative period is essential for optimal surgical outcome. 'Intraoperative adjuvant medications', which is necessary to achieve and maintain adequate anaesthesia, reflected the efficacy as well as the cost–benefit of the anaesthesia protocol used.

'Life-saving' and 'limb-saving' emergency procedures are the primary mandate of healthcare institutions located in areas of need and remote locations. Having orthopaedic surgeons accessible at such institutions and not having a surgical team to address such emergency situations where patients' life or limb can be salvaged with prompt intervention defeats the purpose. Hence, resource optimization and low-risk and effective

solutions are needed to address emergency orthopaedic surgical care. In our institution, the surgical team carried out debridement for mutilated hand injuries, forearm and elbow crush injuries, compound fractures as well as for polytrauma. Internal fixation, vascular and tendon repair were performed, as was emergency fasciotomy for compartment syndrome. Ligamentotaxis with universal forearm external fixator as well as wrist orthofix fixator was done for comminuted intra-articular fractures.

Our results suggest that low risk and efficaciousness of regional anaesthesia are comparable with studies that compared regional anaesthesia with GA.[30,33] However, the uniqueness of our study is that the anaesthesia was administered and the anaesthesia-related complications were managed by a 'non-anaesthetist' in the absence of an anaesthesiologist based on remote pre-anaesthetic consultation and an anaesthesia protocol drawn up through such consultations. An extended learning curve was observed for the AB technique. This study highlights the concept of 'remote pre-anaesthesia consultation' as a means to overcome the lack of anaesthesiologists in remote locations. Telephonic, online and social communication app-assisted consultation, carried out with offsite anaesthesiologists with experience of working in a similar resource-limited healthcare set-up helped us to evolve a pragmatic anaesthesia protocol.

Administration of regional anaesthesia in our series was not entirely uneventful. Twelve patients in our AB cohort had partial block or tourniquet pain and required additional medication. Repeat AB was administered to 2 patients; additional wrist block or metacarpal block was administered to 3 patients and intramuscular pentazocine was administered to 7 patients. Three patients required intravenous ketamine for part of the procedure. One patient developed ulnar nerve palsy with partial recovery at 6-month follow-up. The 'anaesthesia-related complication' rates in our study are similar to the reported incidence of regional anaesthesia-related complications.[13,14] Supervised training, ultrasound guidance and use of nerve stimulators can further lower the risk of complications associated with AB.

However, the study is unable to compare the result and objectively interpret the risk associated with performing surgical procedures without an attending anaesthesiologist. Resources and expertise may vary from centre to centre and this study being a single-centre study, it is difficult to generalize the results.

Conclusions

As we continue to address the prevalent deficit of qualified anaesthesiologists in LMICs, alternative options of low risk and efficacious anaesthesia must be encouraged, and mandatory audit of such instances should be done. This study by no means implies or suggests that safe surgical practice in resource-limited areas can exclude an attending anaesthesiologist. However, in the absence of an anaesthesiologist, AB is a low risk and effective option for anaesthesia when administered by a 'non-anaesthetist' for emergency orthopaedic procedures of the upper limb (hand, elbow and forearm). A prolonged learning curve was shown with AB. Measures such as 'remote pre-anaesthetic consultations' and adjuvant training needs evaluation to lower the risk and enhance the efficacy of AB. We suggest a multicentre study to assess the risk and effectiveness of AB for emergency orthopaedic procedure in centres where there are no anaesthesiologists.

ACKNOWLEDGEMENTS

We would like to thank Dr Rupa Anna, Consultant Anaesthesiology, Pune Adventist Hospital, Pune, Maharashtra, India.

Conflicts of interest. None declared

REFERENCES

1 Iyadurai R, Viggeswarpu S, Zachariah A. Career destination and reason for career destination preferences among medical graduates from Christian Medical College Vellore—Does rural service obligation increase retention of medical graduates in rural service? *J Family Med Prim Care* 2019;**8:**2401–4.
2 Study of Public Health IT Systems in India Background Study for ICT subgroup of Sector Innovation Council in Health. National Health Systems Resource Centre, New Delhi And Taurus Glocal Consulting, New Delhi. Available at *http://nhsrcindia.org/sites/default/files/Regulatory%20study%20report.pdf* (accessed on 5 Sep 2018).
3 Kumar R. Academic institutionalization of community health services: Way ahead in medical education reforms. *J Family Med Prim Care* 2012;**1:**10–19.
4 Datt G, Ravallion M, Murgai R. Revisiting poverty reduction in India with 60 years of Data – Vox EU. Published; 2016. Available at *www.voxeu.org/article/revisiting-poverty-reduction-india-60-years-data* (accessed on 5 Sep 2017).
5 Ravishankar GV. Rural India looking for high quality healthcare. 2012. Available at *www.economictimes.indiatimes.com/industry/healthcare/biotech/healthcare/rural-india-looking-for-high-quality-healthcare/articleshow/11734837* (accessed on 5 Sep 2017).
6 Singh MM, Garg US, Arora P. Laws applicable to medical practice and hospitals in India. *Int J Res Foundation Hosp Healthc Adm* 2013;**1:**19–24.
7 Parakh SC. Legal aspects of anaesthesia practice. *Indian J Anaesth* 2008;**52:** 247–57.
8 Available at *www.mciindia.org/documents/rulesAndRegulations/Ethics%20Regulations-2002.pdf Published2002* (accessed on 5 Sep 2017).
9 Bumb SS, Dodammani A, Jadhav H. Use of anaesthesia in rural India: Constraints that come across. *Int Res J Clin Med* 2016;**1:**17–19.
10 Developing anaesthesia. Available at *www.developinganaesthesia.org/anaesthetic-complications.html* (accessed on 5 Sep 2017).
11 Jadon A. Complications of regional and general anaesthesia in obstetric practice. *Indian J Anaesth* 2010;**54:**415–20.
12 Tennant I, Augier R, Crawford-Sykes A, Ferron-Boothe D, Meeks-Aitken N, Jones K, *et al.* Minor postoperative complications related to anesthesia in elective gynecological and orthopedic surgical patients at a teaching hospital in Kingston, Jamaica. *Rev Bras Anesthesiol* 2012;**62:**188–98.
13 Jeng CL, Torrillo TM, Rosenblatt MA. Complications of peripheral nerve blocks. *Br J Anaesth* 2010;**105** (1 Suppl)**:**i97–i107.
14 Picard J, Meek T. Complications of regional anaesthesia. *Anaesthesia* 2010;**65** (1 Suppl)**:**105–15.
15 Finucane BT, Tsui BC. Complications of brachial plexus anaesthesia. Available at *www.eknygos.lsmuni.lt/springer/598/121-148.pdf* (accessed on 5 Sep 2017).
16 Consensus Statement on Surgical System Strengthening in Rural India. The Lancet Commission on Global Surgery. 2016. Available at *www.lancetglobalsurgery.org/India* (accessed on 5 Sep 2017).
17 Divatia JV. Safe anaesthesia for all Indians: A distant dream? *Indian J Anaesth* 2017;**61:**531–3.
18 Kempthorne P, Morriss WW, Mellin-Olsen J, Gore-Booth J. The WFSA global anesthesia workforce survey. *Anesth Analg* 2017;**125:**981–90.
19 Meara JG, Leather AJ, Hagander L, Alkire BC, Alonso N, Ameh EA, *et al.* Global surgery 2030: Evidence and solutions for achieving health, welfare, and economic development. *Lancet* 2015;**386:**569–624.
20 Panagariya A. The challenges and innovative solutions to rural health dilemma. *Ann Neurosci* 2014;**21:**125–7.
21 Cherian M, Choo S, Wilson I, Noel L, Sheikh M, Dayrit M, *et al.* Building and retaining the neglected anaesthesia health workforce: Is it crucial for health systems strengthening through primary health care? *Bull World Health Organ* 2010;**88:**637–9.
22 Health crisis. India has one of the smallest pools of anaesthesiologists in the world. Available at *www.scroll.in/pulse/838721/india-has-one-of-the-smallest-pools-of-anaesthesiologists-in-the-world* (accessed on 5 Sep 2017).
23 Tongaonker RR. Scope and limitations of rural surgery. *Indian J Surg* 2003;**65:** 38–40.
24 Gokavi S. Medical missions in India today. Available at *www.apcwo.org/newsite/resources/missions/MedicalMissionsInIndiaToday-DrSunilGokavi-EHA.pdf* (accessed on 7 Sep 2017).
25 Raykar NP, Yorlets RR, Liu C, Goldman R, Greenberg SL, Kotagal M, *et al.* The how project: Understanding contextual challenges to global surgical care provision in low-resource settings. *BMJ Glob Health* 2016;**1:**e000075.
26 Surgical care for low-income, rural populations: An alternative delivery model from Jan Swasthya Sahyog, India. Available at *www.globalsurgery.info/wp-content/uploads/2015/08/India-Case-pdf* (accessed on 7 Sep 2017).

27 The Duncan Hospital. Available at *www.duncanhospital-eha.org/THE%20 DUNCAN%20HOSPITAL.pdf* (accessed on 7 Sep 2017).
28 Putturaj M, Prashanth NS. Enhancing the autonomy of Indian nurses. *Indian J Med Ethics* 2017;**2:**275–81.
29 Lewis SR, Nicholson A, Smith AF, Alderson P. Physician anaesthetists versus non-physician providers of anaesthesia for surgical patients. *Cochrane Database Syst Rev* 2014;**7:**CD010357.
30 Adesunkanmi AR. Where there is no anaesthetist: A study of 282 consecutive patients using intravenous, spinal and local infiltration anaesthetic techniques. *Trop Doct* 1997;**27:**79–82.
31 Badejoko OO, Ijarotimi AO, Osinubi RA, Olaleye AO, Ekong EO, Awowole IO, *et al*. Where there is no anaesthetist: The role of obstetrician-administered spinal anaesthesia for emergency caesarean section. *Trop J Obstet Gynaecol* 2013;**30:** 68–74.
32 Harris D. Where there is no anaesthetist. *Trop Doct* 1999;**29:**56–7.
33 Schnittger T. Regional anaesthesia in developing countries. *Anaesthesia* 2007;**62** (1 Suppl)**:**44–7.