Patient satisfaction and quality of pain treatment in the first 24 hours after upper extremity fracture surgery in general or regional anesthesia

Brnic, Luka

UNIVERSITY OF SPLIT
SCHOOL OF MEDICINE

Luka Brnic

PATIENT SATISFACTION AND QUALITY OF PAIN TREATMENT IN THE FIRST 24 HOURS AFTER UPPER EXTREMITY FRACTURE SURGERY IN GENERAL OR REGIONAL ANESTHESIA

Diploma thesis

Academic Year: 2021/2022

Mentor:
Prim. Assist. prof. Mladen Carev, MD, PhD

Split, July 2022

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LIST OF ABBREVIATIONS

UEF – Upper extremity fracture

RA – Regional anesthesia

GA – General anesthesia

ORIF – Open reduction internal fixation

NRS – Numerical rating scale

WHO – World Health Organization

NSAIDs – Non-steroidal anti-inflammatory drugs

NMBA – Neuromuscular blocking agents

TOFR – Train-of-four ratio

LAST – Local anesthetic systemic toxicity

BPB – Brachial plexus blockade

IV – Intravenous

1. INTRODUCTION

1.1. Fractures of the upper extremity

The results from the Global Burden of Disease (GBD) 2019 on fractures show that the three most common anatomical locations for fracture were the lower extremity; patella, tibia or fibula, or ankle, followed by the upper extremity; radius or ulna, or both and finally the last group of fractures; clavicle, scapula, or humerus (1). We can see that the upper extremity fractures constitute two-thirds of the three most common anatomical sites of fractures.

Challenging decisions are made when choosing the appropriate type of anesthesia for upper extremity surgeries and their treatment options. Thus, furthering the understanding of all aspects of fracture management is essential for quality improvement efforts.

1.1.1. Radius

A fall on the outstretched hand loads the body weight on the wrist and forces supination, resulting in a Colles fracture. Radiologically we identify an extra-articular fracture of the distal radius with the fragment being angulated and displaced dorsally (Figure 1A) (2). It is the most common upper extremity fracture and has a bimodal distribution, notably in younger and older age groups; under 18 and over 65, respectively (3). The fracture often occurs in the setting of osteoporosis and is described as a fragility fracture, explaining the high incidence.

The Smith fracture is a reversed Colles fracture where the patient falls with outstretched hands behind his body. The fractured fragment is angulated volarly and sometimes displaced volarly. Figure 1B shows this pronation injury (2).

An intra-articular distal radius fracture accompanied with a radio-carpal joint dislocation would be given the eponymic name Barton fracture. Volar are more common than dorsal fractures (2).

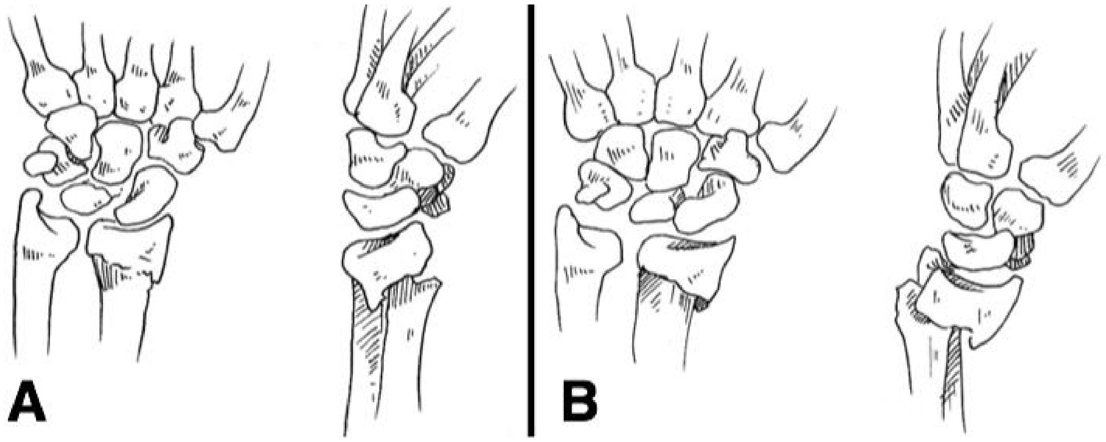

Figure 1. Schematic demonstrating difference in mechanism of injury and bony injury between (A) Colles fracture (B) Smith's fracture (2). *By Aimee Rowe, TeachMeSurgery [CC-BY-NC-ND 4.0].*

1.1.2. Humerus

Proximal humeral fractures are the third most common upper extremity fractures (3). The patient demographic is bimodal and resembles many orthopedic injuries. Young and elderly patients are prone to high-energy trauma and low-impact injuries, respectively. The radial nerve is located in the spiral groove and is at high risk of injury. Higher rates of radial nerve entrapment are seen in Holstein-Lewis fractures of the distal third of the humerus (Figure 2 C) (4).

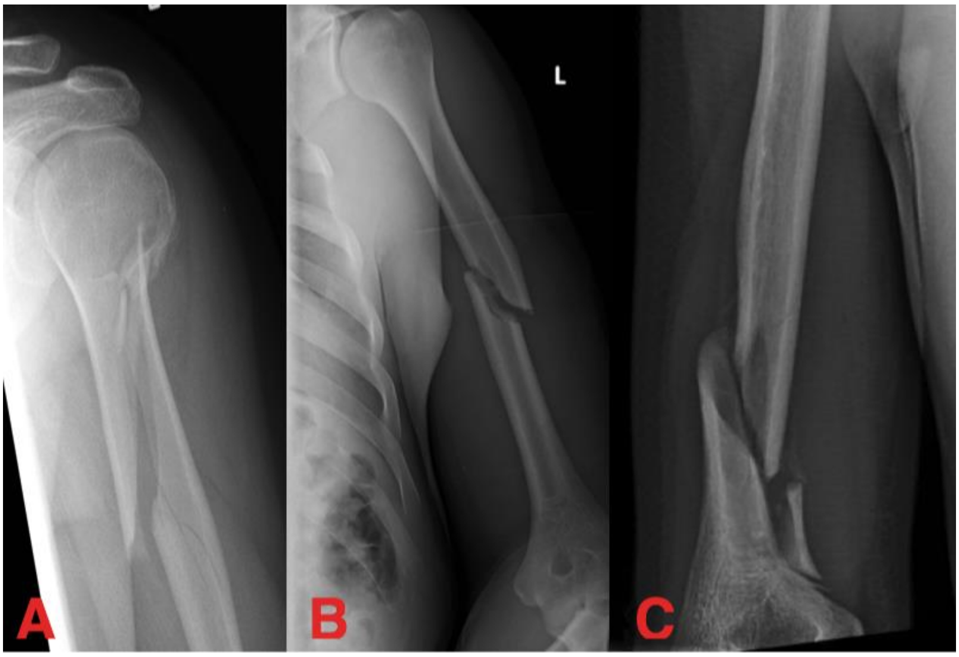

Figure 2. Plain film AP radiographs showing (A) proximal humeral shaft spiral fracture, (B) midshaft humeral fracture (C) distal humeral shaft spiral fracture (a Holstein-Lewis fracture) (4). *Adapted from RSJThompson [CC BY-SA 3.0 (https://creativecommons.org/licenses/by-sa/3.0)], James Heilman, MD [CC BY-SA 4.0 (https://creativecommons.org/licenses/by-sa/4.0)], and Adam of spiralhumerusfracture.blogspot.com/ [Public domain].*

1.1.3. Clavicula

The Allman classification has three types and is used to classify clavicular fractures. Type I is the most common, representing three-fourths of all clavicular fractures. The middle third of the clavicle is the weakest segment thus fracturing the most often (Figure 3). Despite significant deformity, those fractures are generally stable (5).

Whereas in type II, where the lateral third of the clavicle is fractured in 20% of cases and is usually unstable when displaced. Type III occurs in only 5% but has the most potential for complications resulting from the anatomical closeness of the medial third of the clavicle to the mediastinum. Complications include pneumo- or haemothorax and neurovascular compromise (5).

Figure 3. Plain radiograph of left-sided clavicle fracture (5). *By TeachMeSeries Ltd (2022).*

1.1.4. Olecranon

The olecranon is the region of the proximal ulna from its tip to the coronoid process. It articulates with the trochlea of the distal humerus, and all olecranon fractures are therefore intra-articular fractures by definition (6).

These fractures may result from a direct blow to the proximal ulna (Figure 4), or indirectly, via the forceful contraction of the triceps against resistance (typically, during a fall onto an outstretched hand). Less commonly, the olecranon may fracture when the elbow is hyperextended, as the bone is impacted against the olecranon fossa of the distal humerus (7).

Figure 4. An olecranon process fracture, on lateral plain radiograph (6). *By James Heilman, MD [CC BY-SA 4.0 (https://creativecommons.org/licenses/by-sa/4.0)], via Wikimedia Commons.*

1.1.5. Ulna

The eponym Monteggia fracture-dislocation originally referred to a fracture of the shaft of the ulna accompanied by anterior dislocation of the radial head that Giovanni Battista Monteggia of Italy described in 1814. Subsequently, a further classification system based on the direction of the radial head dislocation and associated fractures of the radius and ulna was proposed by Jose Luis Bado of Uruguay in 1958 (8).

Distal ulna fractures are relatively uncommon in isolation, but they are frequently associated with distal radius fractures in the form of ulnar styloid fractures. When distal ulna fractures are isolated, direct trauma causes the so-called "nightstick" fracture, occurring from a focal blow against the soft tissue (9).

1.2. Fracture management

Theories on the optimal timing for moderate compressive axial interfragmentary micromovements or the number of loading cycles to promote bone healing have been studied. Nevertheless, still the most important aspect of bone healing is the anatomical reduction done by internal or external fixation (10,11).

1.2.1. Radius

Immediate closed reduction is always indicated in displaced radial fractures. Local anesthesia is used during the reduction such as haematoma block or Bier's block. Immobilization of the arm is primordial to bone healing; its progression is followed radiographically after one week. Physiotherapy ensues to help the patient rehabilitate.

Unstable or significantly displaced fractures are at risk of displacement are surgically corrected. K-wire fixation, plating or open reduction and internal fixation are some of the surgical options of treatment. Casting is the mainstay of both stable and unstable fractures (2).

1.2.2. Humerus

Conservative treatment in a functional humeral brace is the most common management option for humeral shaft fractures. Casting high above the elbow is indicated in very distal fractures since a humeral brace can act as a fulcrum and may exaggerate the deformity. Criteria defining a fracture as being suitable for conservative management include <20° anterior angulation, <30° varus or valgus angulation, and <3cm of shortening. Full union is expected within 8 to 12 weeks in 90% of patients (4).

The need for surgical fixation is rare but when needed, open reduction and internal fixation with plating are used. Doing so will help the patient return to work slightly faster in comparison to conservative management. In certain conditions, there is a need for the placement of an intramedullary nail like in polytrauma, pathological fractures, or severely osteoporotic bones (4).

1.2.3. Clavicula

As mentioned before, type I Allman fractures of the clavicle are generally stable, therefore conservative treatment is possible. Indeed, studies have shown over 90% bone union even in displaced fractures. In addition, the subcutaneous plate is near the skin surface and requires ablation after bone healing (5).

The patient receives a sling that supports the elbow in place for good healing until he can start pain-free physical rehabilitation. An early mobilization prevents the feared frozen shoulder. Consider that proximal clavicle fractures (type III) need broader management if complications occur (5).

Surgical management is indicated in all open and/or comminuted fractures when significant shortening occurs or when a patient has bilateral fractures. In the last case, the added benefit is the possibility of weight-bearing. The last indication is when the conservative management failed to unite the bone after two or three months since the injury (5).

1.2.4. Olecranon

The amount of displacement on imaging will guide the management of an olecranon fracture. For small displacements <2mm a non-operative treatment is wise. This implies a right angle immobilization of the elbow and as always introduction of movement as soon as possible, here usually after one or two weeks. Patients over the age of 75, no matter the displacement are all treated conservatively since a small degree of extension lost is usually well accepted (6).

On the other side, a displacement >2mm requires operative treatment. This includes tension band wiring (Figure 4) or olecranon plating, depending on the location of the fracture to the coronoid process. Subcutaneous osteosynthetic material is often removed due to discomfort to the patient (6).

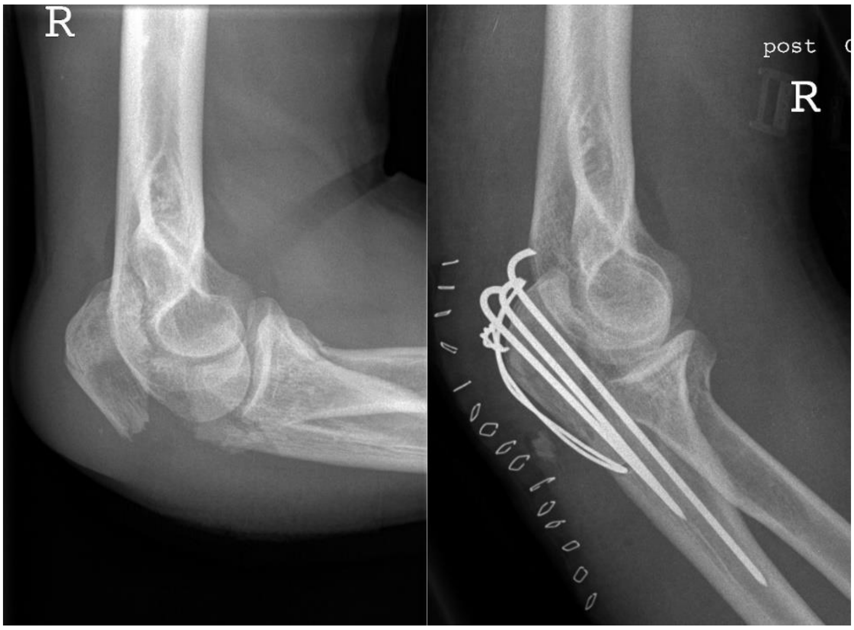

Figure 5. Radiographs of an olecranon process fracture, before and after surgical management (6). *By Michael Müller-Hillebrand / CC BY (https://creativecommons.org/licenses/by/3.0).*

1.2.5. Ulna

The rare isolated ulnar styloid fractures can be treated conservatively. No consensus is made on the conservative versus operative treatment of other distal ulnar shaft and metaphyseal fractures; the decision depends on associated injured structures and the patient's clinical story. Subcutaneous plates, screws, or Kirschner wires will create friction and discomfort to the patient and subsequent removal (9).

Monteggia fracture-dislocation of the elbow is managed by ORIF. Sometimes when the radial head is subluxated, it might mean that the ulnar reduction is incomplete and need to be revisited (12).

1.3. Pain

Current practice has underestimated the role of perioperative complications such as pain in the process leading to morbidity and ultimately death. Prevention of pain has great variability across countries, even institutions and lacks effective drug therapies protocols (13).

1.3.1. Definition

The first definition of pain accepted by the International Association for the Study of Pain (IASP) dates from 1979. Since then, the news insights on pain motivated the ISAP to create a task force in 2018 and in 2020 to modify its definition. This revised definition states: that pain is "an unpleasant sensory and emotional experience associated with, or resembling that associated with, actual or potential tissue damage." This definition is followed by six notes, of which the second one is important in our study: "pain and nociception are different phenomena. Pain cannot be solely from activity in sensory neurons." (14). Indeed, nociception differs from pain as it is the unconscious propagation of a painful stimuli through the nervous system. It produces undesired physiologic stress and hemodynamic instability to the patient under general anesthesia and is therefore to be avoided (15).

1.3.2. Postoperative pain

Postoperative pain is the pain patients feel after a surgical intervention. In a large cohort study, Gerbershagen et al. identified that in 40 procedures out of 179 analyzed, patients reported pain scores of 6-7 (on a numeric rating scale, 0-10). Of those, 22 were extremity orthopedic and traumatological procedures (16). Showing how consequent this problem is in this field.

Many problems emanate from postsurgical pain, such as increased pain medication use, notably the very effective but controversial opioids, decreased patient satisfaction and delayed return to work (1,17).

Secondary to an increased sympathetic drive after the induction of anesthesia and the first incision, the body's homeostasis changes in many ways; the coagulation, inflammation, susceptibility to infection and perfusion of tissues are all altered (13). A major consequence of surgical stressor in orthopedic patients specifically is the deleterious effect pain has on bone healing. Indeed, not only the fracture site stability and bone ends relative approximation are important but also tissue oxygenation. The pseudoarthrosis resulting from bone non-union is painful and leads to a vicious cycle (18).

1.3.3. Treatment

The best practice for treating postoperative pain is following a scheduled dosage plan instead of waiting for the patient's request when pain has occurred. For postoperative patients, the goal is early pain-free ambulation permitting physical rehabilitation. It is recommended to use a multimodal or balanced analgesia combining different types of agents. This minimizes the adverse effects and maximizes the therapeutic profiles of each drug (17). For instance, opioids may lead to adverse effects due to genetic variations in patient's metabolizing enzymes, transporters, receptors and signaling pathways (19).

The guidelines on cancer pain treatment developed by the World Health Organization (WHO) are equally used in non-cancer pain. The WHO analgesic ladder tool first published almost forty years ago (1986), is still in use today but does not constitute a strict protocol (Figure 6) (20).

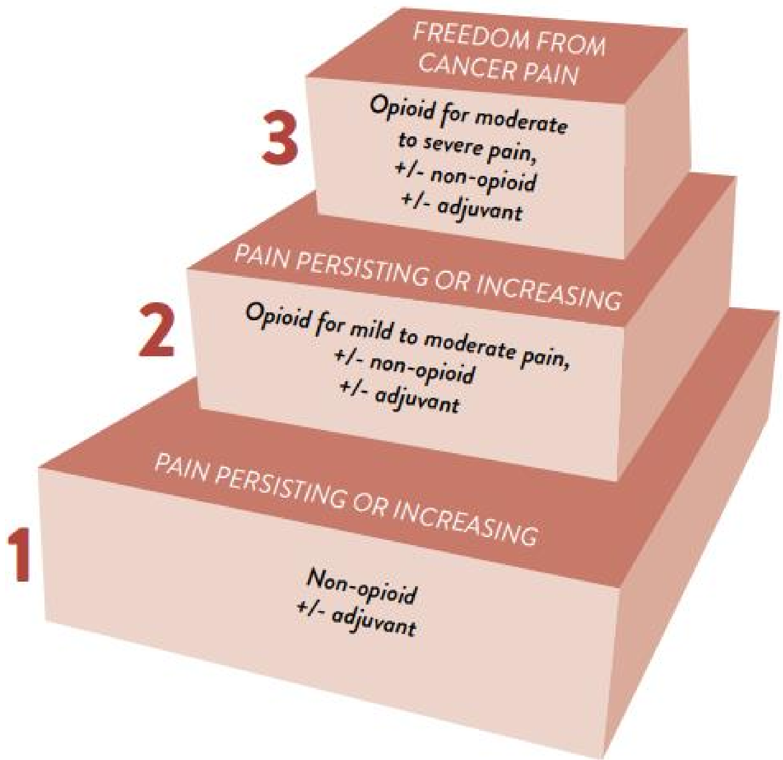

Figure 6. The three-step analgesic ladder from WHO (20)

Nonopioid analgesics include paracetamol and non-steroidal anti-inflammatory drugs (NSAIDs). Examples of commonly used NSAIDs are ibuprofen, ketorolac and acetylsalicylic acid. Opioid analgesics are divided into either weak or strong. Codeine is a good example of a weak opioid. Morphine, hydromorphone. Oxycodone, fentanyl and methadone are strong opioids and should be carefully prescribed as they cause physical dependence in some patients; especially in the setting of renal disease, where the accumulation of some opioids or active metabolites can occur due to prolonged excretion. Adjuvants or co-analgesics are drugs used alone or in combination with the two preceding classes of medications for analgesia. Steroids (dexamethasone, methylprednisolone and prednisolone), antidepressants (amitriptyline and venlafaxine), anticonvulsants like carbamazepine and zoledronate a bisphosphonate are examples of adjuvant treatments (20).

Chou and colleagues from an interdisciplinary panel of experts have identified, reviewed, and presented the best evidence-based recommendations for perioperative pain management in a systematic review. Thirty-two recommendations are divided into general or specific procedures and out of those four have high-quality evidence (recommendations 6, 15, 23 and 26) (21).

Synergizing multiple different analgesics has a superior effect than single drug therapy. For instance, good techniques such as regional anesthesia (peripheral and neuraxial) combined with systemic opioids are recommended. The use of non-opioid and non-pharmacologic modalities are effective and might help reduce opioid consumption, which is often emphasized as a goal (21).

Although animal models showed a link between usage of NSAIDs and bone non-union, there is no high-quality evidence supporting this phenomenon in humans and it is recommended to administer paracetamol and/or NSAIDs to adults and children (21).

The effectiveness of peripheral regional anesthetic techniques in combination with systemic analgesics have been demonstrated in surgeries of the extremities, thorax and abdomen. This recommendation comes with a mention; that elastomeric pumps are prone to failure compared to the modern electric alternative and should therefore be carefully monitored since no alarms exist for those models (21).

1.4. General anesthesia

Long procedure times, inability to perform local or regional anesthesia, short procedures with uncooperative patients and patient's refusal of local or regional anesthesia are all indications for general anesthesia (22). It is important to notice that patient's fears and preferences come into decision-making on the choice between general versus local or regional anesthesia. This is reflected in some studies indicating that the general public has greatly distorted conceptions and concerns on this matter (23). For instance, during our study, patients reported not wanting to hear operating room noises like bone screwing and therefore refusing regional anesthesia.

An anesthetic state in general anesthesia has three major components which are unconsciousness, immobility, and amnesia. This medically induced unconsciousness can be mild or profound in proportion to the concentration of intravenous propofol or the inhalation anesthetic sevoflurane administered. At lower concentrations a mild or sedative effect is achieved through the neuronal activity reduction in the neocortex. A profound or hypnotic effect at higher concentrations results from the action on deeper subcortical structures (24).

Knowing classes and characteristics of anesthetic agents is important for surgeons. Drugs used throughout general anesthesia can be categorized into five types: intravenous anesthetics, inhalational anesthetics, intravenous sedatives, synthetic opioids, and neuromuscular blocking drugs. Profound respiratory depression is the hallmark of the commonly used intravenous anesthetic propofol, "a phenol agent with rapid onset and short duration of action and [it] can be used for induction and maintenance of anesthesia". Its popular usage stems from a pleasant and less commonly agitated emergence from anesthesia compared to sevoflurane and its antiemetic properties (22,25). Etomidate and ketamine are less commonly used due to their side effects; pain, injection site phlebitis, nausea and vomiting and dissociative symptoms respectively. But ketamine has the advantage to also produce intense analgesia (22).

Inhaled anesthetics are used for maintenance of anesthesia but can also be used for induction in patients who fear needles. Sevoflurane and desflurane are the most commonly used inhaled anesthetics due to their safety, absence of major side effects, good pharmacodynamic and pharmacokinetic properties. Nitrous oxide is also a very safe inhaled anesthetic used in the previously mentioned cases of injection anxiety. Brain concentration of anesthetic is directly proportional to its alveolar concentration. The minimal alveolar concentration (MAC) is the concentration of anesthetic in the alveoli that will prevent movement in 50% of patients. A MAC of 1.3 is generally the desired value for maintenance of anesthesia as it prevents response to surgical stimulus in 95% of patients. Emergence, or awakening from anesthesia, occurs when the MAC drops to 0.3 or 0.4 (26-28).

A commonly used preoperative sedative agent in general and regional anesthesia is midazolam, a benzodiazepine with anxiolytic, sedative, and amnestic properties (22).

When manipulation of the airway is possible, the placement of an endotracheal tube ensues. Recent studies suggest that laryngeal mask airway or laryngeal masks are getting more popular as a safe alternative to endotracheal intubation (29).

Synthetic opioids are the most potent antinociceptive agents used during general anesthesia, they are administered intermittently or continuously and in combination with other antinociceptive agents. Combining different agents is the so called balanced general anesthesia and has the advantage of reducing the total amount of each drug and diversifying the mechanism of actions to prevent side effects, notably those of opioids which have also a high prevalence in short-term use. The side effects are constipation, urinary retention, nausea, vomiting, meiosis, bradycardia and the most dangerous in the post-operative setting is the respiratory depression that can be fatal (15,30,31).

Neuromuscular blocking agents (NMBA) are divided into depolarizing and non-depolarizing neuromuscular blocking agents, they differ on their mechanism of action. Depolarizing NMBA, like succinylcholine, bind noncompetitively to the post-synaptic cholinergic receptors on the motor endplate and is commonly used for its short duration of action (7 to 12 minutes) and rapid onset of action (maximum block under a minute), the perfect drug profile for rapid sequence intubations. Non-depolarizing NMBA are competitive antagonists at the post-synaptic cholinergic receptors at the neuromuscular junction with a duration of action greater than 40 minutes. This means that by increasing the concentration or the half-life of acetylcholine in the synaptic cleft we can reverse the blockade. An important monitoring tool is the train-of-four ratio (TOFR) which tells us if a reversal agent is needed. A common reversal agent is the acetylcholinesterase inhibitor neostigmine. Possible potentiation of non-depolarizing NMBA are possible with prolonged exposure to sevoflurane and isoflurane (22,32,33).

1.5. Regional anesthesia

Regional anesthesia has many advantages, such as greater rates of home discharges, lower rates of complications, lower readmission rates and shorter hospital stays compared to general anesthesia (34,35). It also bypasses the need for airway manipulation and all the physiologic changes described in general anesthesia (22). However, opting for this method as an alternative to general anesthesia poses some challenges. For instance, the patient must consent, the surgeon must be experienced and comfortable with a patient that is awake, and the anesthesiologist must have the skills to perform the right form of regional anesthesia (36).

Ultrasound guided regional anesthesia is a very instinctive procedure. The anesthesiologist has to administer the right amount of local anesthetic at the right location, and this is possible with the direct visualization of the nerve, arteries and veins. It then shows in real time the spread of the injected local anesthetic form the tip of the needle to the intended site. It is sensitive to anatomical variants and reduces the risk of local anesthetic systemic toxicity (LAST) (37,38).

LAST can be life threatening as it first interferes with the central nervous system by disrupting the sodium voltage channels in the cortical inhibitory pathways leading to uncontrolled excitatory events (muscle activation, seizures) followed by disruption of the excitatory pathways which then produce depressive events (loss of consciousness, coma, respiratory arrest). Cardiovascular toxicity is mediated by the same disturbance but in the bundle of His, in this case producing arrhythmias (39).

The brachial plexus is a very complex structure that has many anatomical variations. Feigl et al. take a structured practical approach to preforming an ultrasound guided brachial plexus block. Four techniques of brachial plexus blockade (BPB) are described, the interscalene BPB indicated in shoulder surgery, the supraclavicular BPB used in any upper extremity surgery, the infraclavicular BPB for the elbow and distal regions and the axillary BPB which is the most customizable block since single nerves can be targeted (40,41).

Regional anesthesia is also an excellent choice for distal radius fracture surgeries, for patients with cardiopulmonary risk factors and patients who previously had complications from general anesthesia (42). A study showed that regional anesthesia also helped the early painless mobilization of the wrist and fingers. They even think the choice of anesthesia (regional versus general) may help the patient to have improved function when assessed 3 and 6 months postoperatively and quicker return to activities in the case of regional anesthesia (43).

The rebound pain phenomenon is addressed by good pre-operative planning and discussion with the patient. The patient must be informed that when the regional anesthesia dissipates, the pain will come but can be avoided by early bridging with oral analgesics (44).

2. OBJECTIVES

The purpose of this study is to investigate patient satisfaction and quality of pain treatment in the first 24 hours after upper extremity fracture surgery in general or regional anesthesia based on:

1. Separation of patients into two groups: regional anesthesia (RA) group and general anesthesia (GA) group.

2. The close monitoring of pain using the Numerical rating scale (NRS) results at five different times: pre-operation, 2, 6, 12 and 24 hours in both groups.

3. Results of the questionnaire on general satisfaction and satisfaction of pain management.

Hypotheses:

1. There is a significant reduction of pain in the regional anesthesia (RA) group compared to the general anesthesia (GA) group in the level of pain measured by the NRS scale during the first 2, 6, 12 and 24 hours postoperatively.
2. There is an association between the treatment satisfaction and regional anesthesia (RA).
3. There is a significant reduction of pain in the regional anesthesia (RA) group compared to the general anesthesia (GA) group in the least pain experienced over the first 24 hours, the worst pain experienced over the first 24 hours, the percentage of time spent in severe pain and the percentage of pain relief achieved over the first 24 hours.

3. MATERIALS AND METHODS

3.1. Study Design and Participants

This prospective non-randomised study was performed at the University Hospital of Split location Firule in Croatia in the period from 14 December 2016 to the 17 December 2017. Ethical approval for this study (Ethical Committee N° 2181-147-01/06/M.S.-17-2) was provided by the Ethical Committee of the University Hospital of Split, Split, Croatia (Chairperson Prof. Dr. Sc. Marijan Saraga) on 20 April 2017. All patients provided written informed consent.

This study compares the following parameters in UEF in RA or GA groups:

- Pain severity
- Evolution of pain
- Treatment satisfaction

Subjects are all patients that underwent osteosynthesis for an isolated upper extremity fracture in KBC Split. 120 were enrolled in the study. Patients hypersensitive to local amide-type anesthetics were automatically assigned to the general anesthesia group.

Inclusion criteria:

- Patients with isolated upper extremity fracture who required surgical treatment
- ASA (American Society of Anesthesiologists) grade 1 to 3
- Patients older than 18 years

Non-inclusion criteria:

- Patients with polytrauma
- ASA grade 4 and above
- Pregnant women
- Patients under 18 years of age
- Patients with mental and neurological diseases that make it impossible to understand research

Exclusion criteria:

- Patients desiring to withdraw from the study
- Conversion of regional to general anesthesia

3.2. Procedure

Patients were divided into two groups: operated under general anesthesia (GA) and operated under regional anesthesia (RA). All patients were asked about their pain using a numerical rating scale (0 to 10) before the operation, 2, 6, 12 and 24 hours postoperatively. In the end the “Revised American Pain Society Patient Outcome” questionnaire was filled out to assess the quality and satisfaction of postoperative pain management. Both types of anesthesia were performed according to the usual protocol.

For GA, fentanyl, propofol, midazolam, and vecuronium were used for induction of anesthesia, and inhaled sevoflurane with bolus doses of fentanyl and vecuronium as needed to maintain anesthesia. During the operation, the patient was monitored according to the ASA protocol. Half an hour before the end of the operation, the patient would receive an analgesic (metamizole 2.5 g IV). After the operation, the patient was observed in the postanesthesia care unit and after 45-90 minutes was taken to his/her room. Intravenous (IV) analgesia continued in the room according to the protocol: metamizole 2 x 2.5 g IV and paracetamol 3 x 1 g IV. After 24 hours, the patient was prescribed ibuprofen 2-3x 400 mg tablet per os, and the combination of tramadol and paracetamol 75/650 mg as needed (maximum 3 tablet /day).

For RA, depending on the type of fracture, regional blocks of the brachial plexus and cervical plexus were applied. All procedures were performed under ultrasound control. After sterile washing of the field, 2 ml of 2% lidocaine was applied to the injection site. A G21 size needle with an adapted tip for better visibility under ultrasound was used for the nerve block. Among local anesthetics, levobupivacaine 0.5% 10-30 ml was used depending on the level of brachial plexus blockade. After assessing the success of the block, the surgical procedure would begin. During the operation, the patient was monitored according to the ASA protocol. After the operation, the patient was observed in the postanesthesia care unit and after 45-90 minutes was taken to his/her room. In the first 24 hours, the patients received paracetamol 3 x 1 g IV and metamizole 2.5 mg IV if necessary. After 24 hours, the patient was prescribed ibuprofen 2-3x 400 mg tablet per os, and the combination of tramadol and paracetamol 75/650 mg as needed (maximum 3 tablet /day).

3.3. Methods of Collecting and Analyzing Data

The study material was collected at the Department of Anesthesiology and Intensive Care of the University Hospital of Split location Firule. Paper questionnaires were gathered and typed in the Microsoft Excel program.

To assess the pain, we used the Numerical rating scale (NRS) at five different times: pre-operation, 2, 6, 12 and 24 hours postoperatively in both groups. The scale ranges from 0 if the patient experienced no pain to 10 if the patient experienced the worst pain possible. To assess the general satisfaction and satisfaction of pain management we asked every patient at the end of the first 24 hours to complete the "Revised American Pain Society Patient Outcome" questionnaire translated into Croatian. The questionnaire is comprised of thirteen questions also rated from 0 to 10, depending on the question the answer on the scale are re-defined to match the question.

Statistical analyses were performed using MedCalc Statistical Software, version 20.0.13.0. (Medcalc Software, Oostende, Belgium), and JASP software 0.16.1. (JASP team, Amsterdam, Netherlands, 2022). All the descriptive data was expressed as percentage or the number of patients, or as median value with 95% confidence interval. Continuous variables were analyzed with Mann-Whitney U test after a normality test, whilst categorical variables were analyzed using Chi-squared test. Numeric rating pain scale values were analyzed using two-way repeated measures analysis of variance (RM-ANOVA). Statistical significance of P value was set at <0.05.

3.4. Primary Outcomes

The primary outcomes are satisfaction and quality of pain treatment in the first 24 hours after upper extremity fracture surgery in general or regional anesthesia.

3.5. Secondary Outcomes

The secondary outcomes are anatomic site of fractures, demographic and gender distribution of fractures and type of anesthesia used for each fracture type.

4. RESULTS

A total of 120 patients were included in our study. Patients were distributed equally in two groups 61 and 59 patients in general and regional anesthesia, respectively as shown on subject flow diagram in Figure 7 below.

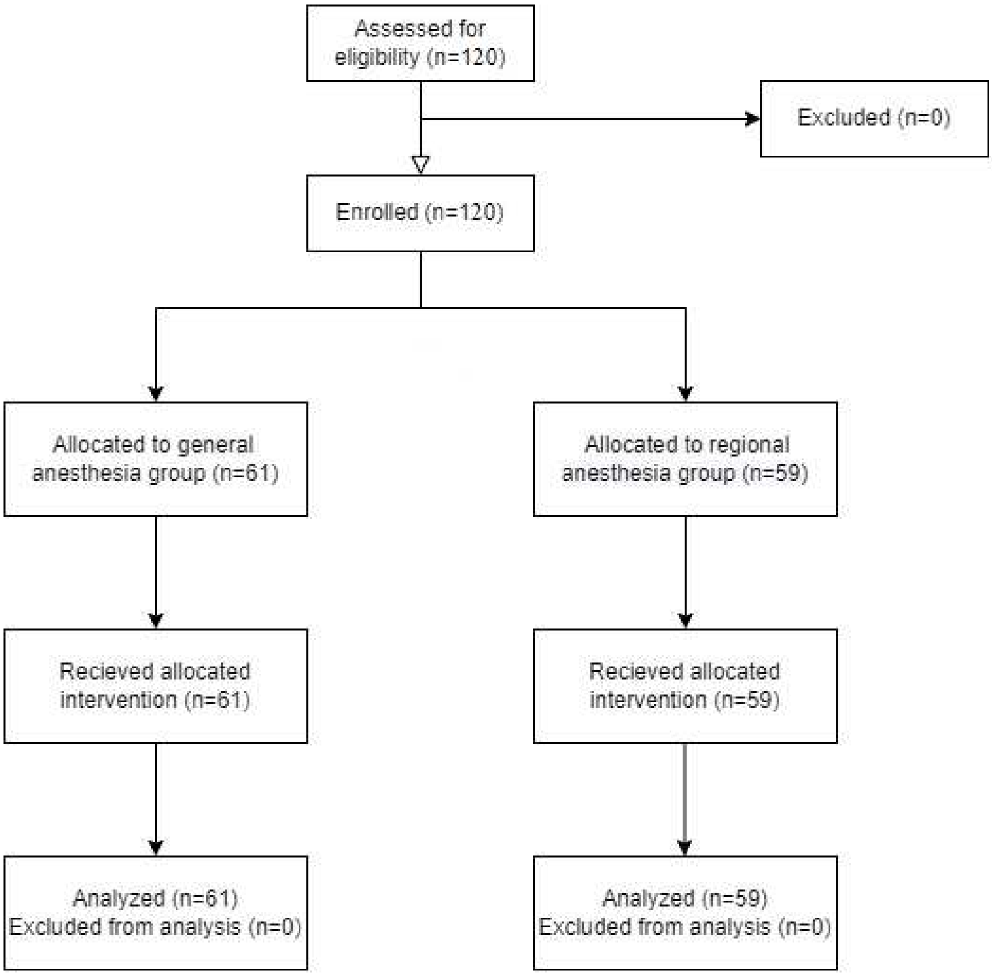

Figure 7. Subject flow diagram

Patient demographics and clinical characteristics are given in Table 1 and show a male predominance in both groups. In both groups the age was equally distributed. About one out of five patients had an emergency surgery in both groups.

Table 1. Patient Demographics and Clinical Characteristics

	GA group (n=61)	**RA group (n=59)**	***P***
Sex (M/F)	44/17	37/22	0.271
ASA (I/II)	29/31*	24/35	0.401
Age (year) (Md, IQR)	53 (33-64)	58 (42.5-69)	
Emergency (n, %)	14 (22.95%)	11 (18.64%)	0.561

Note. GA – general anesthesia, RA – regional anesthesia, Md – Median, IQR – Interquartile range

*one missing

The occurrence of diagnoses as indication for surgery are given in Table 2. The most common fracture in our study was the radius as larger studies have identified to be the most common in a general population (1). Since we did not include hand fractures in this study second most common fracture in our study group was humeral shaft fracture (3).

Table 2. Occurrence of Diagnoses as Indication for Surgery

Diagnosis (%)	GA group (n=61)	RA group (n=59)
Radius	26 (42.52%)	25 (42.37%)
Humerus	19 (31.15%)	22 (37.29%)
Clavicula	9 (14.75%)	6 (10.17%)
Olecranon	4 (6.56%)	3 (5.08%)
Ulna	3 (4.92%)	1 (1.69%)
Other	0 (0.00%)	2 (3.39%)

Note. GA – general anesthesia, RA – regional anesthesia

The NRS scale scores for both groups are shown in Table 3 and graphically represented in Figure 8. After using the RM-ANOVA test (Table 4) we can see that both groups had the same pre-operative pain levels, but the RA had no pain in the next three times they were asked after the operation compared to the GA group. At 24 hours both groups reported a similar level of pain.

Table 3. NRS scale scores

NRS time (Md, 95% CI)	GA group (n=61)	RA group (n=59)	*P**
Pre-op	6 (6-7)	6 (6-7)	0.647
2 hours after	4 (3-5)	0 (0-0)	<0.001
6 hours after	5 (5-6)	0 (0-0)	<0.001
12 hours after	4 (4-5)	0 (0-0)	<0.001
24 hours after	3 (2-3)	2 (2-2)	0.003

Note. NRS - Numerical rating scale, GA – general anesthesia, RA – regional anesthesia, Md – Median

*Mann-Whitney U test

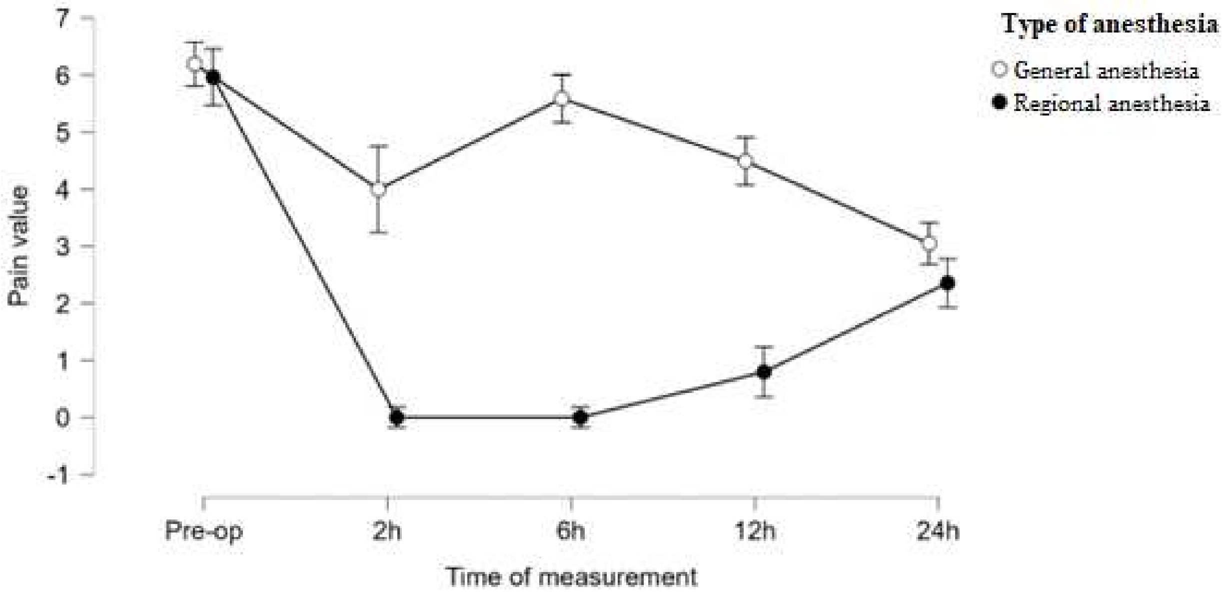

Figure 8. Pain values on NRS scale during post-operative recovery

Table 4. RM-ANOVA analysis on pain values on NRS scale during post-operative recovery, filtered by type of anesthesia

Cases	Sum of Squares	df	Mean Square	F	*P*
Repeated measures Factor 1	1253.997	4	313.499	109.157	< 0.001
Repeated measures Factor 1 (Filter) Type of anesthesia	631.557	4	157.889	54.975	< 0.001
Type of anesthesia	1211.076	1	1211.076	195.249	< 0.001
Residuals	1355.586	472	2.872		

Note. Type III Sum of Squares

Results for the questionnaire on satisfaction can be seen in Table 5. We can note that when patients were asked: what was the worst pain they experienced in the first 24 hours, the regional group answered in average 4 compared to 7 out of 10 in the general group. The general group had troubles in and out of bed as well as falling and staying asleep compared to virtually no troubles in the regional group. One more notable difference is that in the regional group answered 100% to the question " how much relief you have received from all of your pain treatments combined", compared to 70% in general group. This shows a great satisfaction in pain treatment in the regional group compared to the general group.

Table 5. Results from the Revised American Pain Society Patient Outcome questionnaire

Rating (Md, 95% CI)	GA group (n=61)	RA group (n=59)	*P*
Min pain 24h	3 (2-3)	0 (0-0)	<0.001
Max pain 24h	7 (7-8)	4 (4-5)	<0.001
% severe pain	2 (1-3)	1 (0-1)	<0.001
Pain interference – in bed	7 (5-8)	0 (0-1)	<0.001
Pain interference – out of bed	3 (2-5)	0 (0-1)	<0.001
Pain interference – falling asleep	5 (3-7)	0 (0-1)	<0.001
Pain interference – staying asleep	5 (4-8)	1 (0-2)	<0.001
Pain – anxious	0 (0-0)	0 (0-0)	<0.001
Pain – depressed	0 (0-0)	0 (0-0)	0.004
Pain – frightened	0 (0-2)	0 (0-0)	<0.001
Pain – helpless	0 (0-2)	0 (0-0)	0.003
Nausea	1 (0-2)	0 (0-0)	<0.001
Sleepiness	0 (0-2)	0 (0-0)	<0.001
Pruritus	0 (0-0)	0 (0-0)	0.995
Dizziness	0 (0-0)	0 (0-0)	0.001
Pain relief 24h	7 (6-9)	10 (10-10)	<0.001
Participation in pain management	10 (6-10)	10 (10–10)	0.033
Satisfaction	8 (6-9)	10 (10-10)	<0.001
Information helpful	8 (7-8)	10 (10-10)	<0.001

Note. GA – general anesthesia, RA – regional anesthesia, Md – Median

Tables 5 show that three times more patients used non-medical pain relief in the GA group compared to the regional group. Whereas information about medical pain management was received in majority of patients in both groups. Table 6 show that sometimes nurses would encourage non-medical pain relief slightly more in the general group compared to the RA group.

Table 5. A few various questions

n (%)	GA group (n=61)	RA group (n=59)	*P*
Informed about pain management	56 (91.80%)	57 (96.10%)	0.189
Non-medical pain relief	23 (37,70%)	7 (11.86%)	0.011

Note. GA – general anesthesia, RA – regional anesthesia

Table 6. Non-medical pain relief – comparison between GA and RA groups

Encouraged by	Never		Sometimes		Often	
	GA	**RA**	**GA**	**RA**	**GA**	**RA**
Doctor	56 (91.80%)	58 (98.31%)	5 (8.20%)	1 (1.69%)	0 (0%)	0 (0%)
Nurse	47 (77.05%)	52 (88.14%)	10 (16.39%)	7 (11.86%)	4 (6.56%)	0 (0%)
Other	47 (77.05%)	51 (86.44%)	6 (9.84%)	5 (8.47%)	8 (13.11%)	3 (5.09%)

Note. GA – general anesthesia, RA – regional anesthesia

5. DISCUSSION

In this prospective non-randomised study 120 patients undergoing an orthopedic upper extremity fracture surgery for an isolated fracture were included, of whom 61 underwent a general and 59 a regional anesthesia. The primary objective of this study was to compare whether the satisfaction and quality of pain treatment in the first 24 hours after an orthopedic upper extremity fracture surgery was influenced by the type of anesthesia chosen.

In the realm of upper extremity fracture surgery there are only a few studies investigating the effect of the choice between general or regional anesthesia on postoperative pain and patients' satisfaction (45-50). Our study inserts into this line of queries in an effort to further the understanding of all aspects of perioperative pain management.

Direct measure of pain through different self-assessment questionnaires are used in similar studies as ours, for example the Quality of Recovery-40 (QoR-40K) questionnaire (45), QuickDASH, health related quality of life SF12v2 (47), EuroQol-5 Dimensions-3 Levels (EQ-5D-3L) (48). Examples of indirect measure of pain are: fast-track eligibility, duration of stay in the postanesthesia care unit and time to first analgesic request (46). In our study, we focused on the Numerical rating scale (NRS) results and the "Revised American Pain Society Patient Outcome" questionnaire. Using RM-ANOVA test we showed a statistically significant reduction in pain in the regional anesthesia (RA) group compared to the general anesthesia (GA) group in the level of pain during the first 2, 6, 12 and 24 hours postoperatively. At 24 hours postoperatively the statistical significance decreases slightly probably because the effect of the RA is dampening.

The results of the questionnaire also showed that regional anesthesia (RA) is associated with a better treatment satisfaction compared to general anesthesia (GA). In addition, there is a statistically significant reduction of pain in the regional anesthesia (RA) group in the least pain experienced over the first 24 hours, the worst pain experienced over the first 24 hours, the percentage of time spent in severe pain and the percentage of pain relief achieved compared to the general anesthesia (GA) group.

The goal was achieved, and our hypotheses are confirmed. We determined that regional anesthesia is superior to general anesthesia for patient satisfaction and quality of pain treatment in the first 24 hours after upper extremity fracture surgery. This is a result that is in accordance with most studies cited and confirms that regional anesthesia should be preferred for the many advantages it offers over general anesthesia. Apart from the direct effect of reduced pain after surgery, regional anesthesia also spares the patient from airway manipulation needs and physiologic stress of the general anesthesia state (22,24).

Some could argue the use of only one data source, being the self-assessment questionnaire, doesn't show good evidence. This is not an issue since our study has a large sample size for the very selective inclusion criteria "isolated upper extremity bone fracture" and we used five different assessments in the first 24 postoperative hours. Doo AR et al. had a sample size of 97, McCartney C et al. 100, Wong SS et al. 100, Wong SS et al. 52, Rundgren J et al. 88, Hadzic A et al. 52 and O'Donnell DB et al. had 30 patients included in the study.

In addition, there was no statistically significant difference between the two groups when comparing patient demographic and clinical characteristics: the sex, ASA score, emergency and the age was similar.

McCartney C et al. assessed the pain postoperatively in increments of 30 minutes starting as early as 30 minutes after anesthesia and going up the second hour. This seems too precipitated and exposes the study to lower quality results from the general anesthesia group which might be drowsy at emergence from anesthesia. Good indirect measures of pain however are worth mentioning from this study. Those are: fast-track eligibility, duration of stay in the postanesthesia care unit and time to first analgesic request (46). Larger timeframes (day 1 to day 7 and 14) used in this study showed there was no difference in pain between regional and general anesthesia. This goes beyond the most studied timeframe but is also an important finding to keep in mind and potentially investigate to corroborate or disprove the results.

Wong SS et al. used a two days' time frame and managed to also show the superiority of regional over general anesthesia. Interestingly, the oral analgesic had no notable difference (47).

Similarly, to our study, Rundgren J et al. showed a statistically significant reduction in postoperative pain in the regional anesthesia (RA) group compared to the general anesthesia (GA) group (48).

The study from Hadzic A et al. shows a drastic increase in the need for pain treatment in the general anesthesia (GA) group. This group asked 48% of the time compared to zero in the regional anesthesia (RA) group (49).

O'Donnell BD et al. confirmed that regional anesthesia is a superior alternative to general anesthesia in upper extremity trauma surgeries (50).

On the subject of study design in comparison to the most similar study to ours done by Doo AR et al., our study has a closer monitoring of pain in a shorter period of time but our study would have benefited from the judicious use of telephone follow up after discharge (45).

A bit outside the study subject, RA can be used as an analgesic technique after of in conjunction with GA (51, 52).

A limitation of our study is that our methodology relied exclusively on questionnaire and therefore our results, although showing statistically significant difference with a decent sample size, are too exposed and dependent on patients understanding and cooperation to answer most sincerely and accurately. For example, some patients might have lied about some data points not to appear too harsh. Some patients might have endured some pain to be polite and not complaint too much. Those are also country sensitive, since the two last examples are taken from patients' commentaries. The additional use of indirect measures of pain as mentioned before ; fast-track eligibility, duration of stay in the postanesthesia care unit and time to first analgesic request (46) but also analgesic use during home recovery are more objective but for some are more resource consuming.

6. CONCLUSIONS

1. RA is superior to GA for the patient satisfaction and quality of pain treatment in the first 24 hours after upper extremity fracture surgery.
2. After 24 hours both groups GA and RA come to a similar pain score.
3. There was a male predominance for upper extremity fracture in both groups GA and RA.
4. The University Hospital of Split location Firule in Croatia is a good sample for representing the world numbers in terms of fracture occurrence.

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8. SUMMARY

OBJECTIVES: in this prospective non-randomized study we compared the quality of postoperative pain treatment and satisfaction in the first 24 hours after upper extremity surgery under general or regional anesthesia.

MATERIALS AND METHODS: Hundred and twenty subjects, aged 18–90 years and American Society of Anesthesiologists physical status I or II, undergoing orthopedic upper extremity surgery, were allocated to general or regional anesthesia group. Patients were asked at five different times about their pain using a numerical rating scale (0 to 10) preoperatively, 2, 6, 12 and 24 hours postoperatively. A validated Croatian version of the "Revised American Pain Society Patient Outcome" questionnaire was used to assess the quality and satisfaction of postoperative pain management. Finally, the scores of both groups were compared.

RESULTS: We analyzed 61 and 59 patients in general and regional anesthesia group respectively. The level of pain was statistically significantly different between the two groups at 2, 6, 12 and 24 hours postoperatively ($P<0.001$). We found an association between postoperative pain management satisfaction and regional anesthesia ($P<0.001$).

CONCLUSION: The present study suggests that RA is superior to GA and improves the evolution of pain and quality of postoperative recovery.

9. CROATIAN SUMMARY

NASLOV: Zadovoljstvo bolesnika i kvaliteta liječenja boli u prvih 24 sata nakon operacije prijeloma gornjeg ekstremiteta u općoj ili regionalnoj anesteziji.

CILJEVI: u ovoj prospektivnoj nerandomiziranoj studiji usporedili smo kvalitetu liječenja postoperativne boli i zadovoljstvo u prva 24 sata nakon operacije gornjih ekstremiteta u općoj ili regionalnoj anesteziji.

MATERIJALI I METODE: Sto dvadeset ispitanika, u dobi od 18 do 90 godina i fizičkog statusa I ili II Američkog društva anesteziologa, koji su imali ortopedskoj operaciji gornjih ekstremiteta, raspoređeni su u skupinu opće ili regionalne anestezije. Pacijenti su u pet različitih vremena upitani o svojoj boli korištenjem numeričke ljestvice ocjenjivanja (0 do 10) prije operacije, 2, 6, 12 i 24 sata nakon operacije. Validirana hrvatska verzija upitnika "Revised American Pain Society Patient Outcome" upitnik je korištena za procjenu kvalitete i zadovoljstva liječenja postoperativne boli. Na kraju su uspoređeni rezultati obiju skupina.

REZULTATI: Analizirali smo 61 bolesnika u općoj i 59 bolesnika u skupini regionalne anestezije. Razina boli bila je statistički značajno različita između dvije skupine 2, 6, 12 i 24 sata postoperativno (P<0,001). Pronašli smo povezanost između zadovoljstva postoperativnim liječenjem boli i regionalne anestezije (P<0,001).

ZAKLJUČAK: Ova studija sugerira da je RA superiorniji od GA i poboljšava razvoj boli i kvalitetu postoperativnog oporavka.

10. CURRICULUM VITAE

Luka Brnic - 21.07.1993

Born and educated in Yverdon-les-Bains, Switzerland

Parents origin : Croatians from Posavina County in Bosnia, naturalized Swiss in 2018

Tennis, volleyball, and guitar

Education

Gymnase d'Yverdon — Switzerland

July 2013

University of Split School of Medicine (USSM) — Croatia

2016 – 2022

Professional experience — Switzerland

Elderly meal delivery service at CMS

(Centre Medico Social) — Yverdon, Grandson

2011 – 2014

- Contact with the elderly
- Teamwork
- Punctuality

Internship as a hospital soldier in the Swiss Army — CTR du CHUV – Sylvana

2015 (1 month)

- First steps in a hospital
- Contact and toilet of rehabilitation patients
- Discipline and rigor

Caregiver with the Red Cross certificate — EMS JPL d'Yverdon

2016 (3 months)

- Animation and toilet of patients in EMS
- Long hours
- Communications

Languages

- French, Croatian, English, German fluency
- 8 months of linguistic travel for German and English + linguistics as a hobby