

Target-controlled infusion (Propofol) versus inhaled anaesthetic (Sevoflurane) in patients undergoing shoulder arthroscopic surgery

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ABSTRACT

Background: One of the challenges of anaesthesia for shoulder arthroscopic procedures is the need for controlled hypotension to lessen intra-articular haemorrhage and thereby provide adequate visualisation to the surgeon. Achievement of optimal conditions necessitates several interventions and manipulations by the anaesthesiologist and the surgeon, most of which directly or indirectly involve maintaining intra-operative blood pressure (BP) control. **Aim:** This study aimed to compare the efficacy and convenience of target controlled infusion (TCI) of propofol and inhalational agent sevoflurane in patients undergoing shoulder arthroscopic surgery after preliminary inter-scalene blockade. **Methods:** Of thirty four patients studied, seventeen received TCI propofol (target plasma concentration of 3 µg/ml) and an equal number, sevoflurane (1.2-1.5 Minimum Alveolar Concentration). N₂O was used in both groups. Systolic, diastolic, mean blood pressures and heart rate were recorded regularly throughout the procedure. All interventions to control BP by the anaesthesiologist and pump manipulation requested by the surgeon were recorded. The volume of saline irrigant used and the haemoglobin (Hb) content of the return fluid were measured. **Results:** TCI propofol could achieve lower systolic, mean BP levels and the number of interventions required was also lower as compared to the sevoflurane group. The number of patients with measurable Hb was lower in the TCI propofol group and this translated into better visualisation of the joint space. A higher volume of saline irrigant was required in the sevoflurane group. No immediate peri-operative anaesthetic complications were noted in either category. **Conclusion:** TCI propofol appears to be superior to and more convenient than sevoflurane anaesthesia in inter-scalene blocked patients undergoing shoulder arthroscopy.

Key words: Intravenous anaesthetic, propofol, shoulder arthroscopy, sevoflurane, target control infusion, volatile anaesthetic

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INTRODUCTION

Anaesthesia for shoulder arthroscopic surgeries is challenging due to factors such as difficulty in patient positioning, remote access for airway and complications specific to the procedure. Bones bleed at normotension and the shoulder joint is a highly vascular area. An exceptional problem faced during arthroscopic surgery of the shoulder is the inability to use a tourniquet to control bleeding, thereby necessitating the use of

manoeuvres like inter-scalene block,^[1] adrenaline in saline irrigation,^[2] or hypotensive anaesthesia,^[3] to create a bloodless field for adequate visualisation of the joint. Literature does mention the use of inhaled anaesthetic techniques combined with pharmacological agents (isoflurane and β-blocker, labetalol) to achieve target blood pressures during such surgeries.^[3] There is little information on the use of intravenous propofol for shoulder arthroscopy as the primary anaesthetic agent. Souron and colleagues,^[4] reported the use of target

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control infusion (TCI) of propofol as a sedative during shoulder surgery under inter-scalene brachial plexus block. TCI propofol and single agent anaesthesia with sevoflurane have been compared by different authors,^[5] for spine surgeries, but in patients who received no regional anaesthesia. Medline search did not show any studies comparing the use of TCI propofol versus conventional inhalational techniques for shoulder arthroscopic surgeries in patients who received concomitant inter-scalene brachial plexus block. Our study was aimed to compare the efficacy (in terms of achieving the haemodynamic status required) and convenience (with respect to manipulations required by anaesthesiologist for maintaining the blood pressures or by surgeon, changing the operative environment) of TCI propofol and inhalational agent sevoflurane in patients undergoing shoulder arthroscopic surgery after preliminary regional inter-scalene blockade.

METHODS

The study was approved by the Institute Ethical Committee. Thirty seven consecutive patients who were anaesthetised by a single anaesthesiologist and operated upon by a single surgeon, undergoing shoulder arthroscopic surgery over a thirteen month period (November, 2010-December, 2011) were considered for the study. A minimum of sixteen patients were required in each group in order to detect the mean difference of 10 mm of Hg blood pressures (power 80%, α 0.05, β 0.20, with standard deviation of 10 in each group). Selection of the patients was done as shown in the consort chart [Figure 1]. Patients having American Society of Anesthesiologists (ASA) status 1 and 2 were included in our study. Since preliminary inter-scalene block formed an essential part of the anaesthetic procedure in

all subjects, 3 patients in whom the regional block was considered less than optimally effective were excluded from the study. Incidentally, one of these 3 had severe local pain at the operative site soon after termination of anaesthesia, confirming the ineffectiveness of the block and unsuitability for inclusion in the study. Seventeen of the thirty four patients who qualified for inclusion underwent anaesthesia using TCI propofol and an equal number was subjected to inhalational anaesthesia with sevoflurane. After pre-operative assessment and recording of baseline vitals, patients were pre-medicated with tab. Ranitidine 150 mg, having fasted for 8 hours prior to the surgical procedure. No sedatives or opioids were used as pre-medicants.

In the operating room, patients were administered intravenous (IV) inj. fentanyl 2 μ g/kg. Inter-scalene block (modified Winnie's) was performed using the nerve locator, in supine position, with a local anaesthetic mixture containing 6 ml of lignocaine 2%, 35 ml of bupivacaine 0.25% and hyaluronidase 1500 International Units. The effectiveness of the block was confirmed by abolition of sensations (pinprick) over C₄-C₇ dermatomes and/or free and painless (passive) abduction in patients with painful shoulders. Subjects were induced either with IV bolus doses of inj. propofol 2 mg/kg (sevoflurane group) or with TCI pump device (EVADROP TCI syringe pump, Schiller, UK), (TCI Propofol group) after confirming the effectiveness of regional anaesthesia. The patient's demographic data was entered into the TCI unit and to facilitate the induction, the target propofol plasma concentration for induction, 8 μ g/ml was used. Tracheal intubation was facilitated using IV inj. vecuronium or rocuronium in 2 ED₉₅ doses and ventilation was aimed to achieve normo-carbia. Three lead electrocardiogram, SpO₂, non-invasive blood

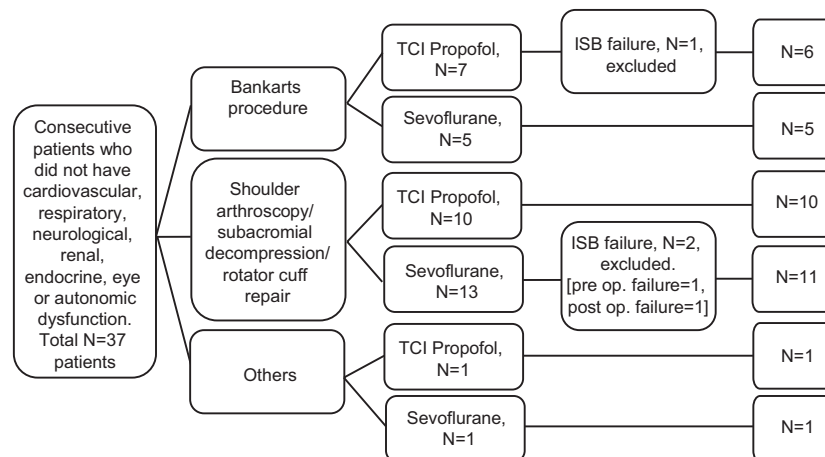


Figure 1: Consort chart showing the distribution of patients in both groups. Within a procedural category, patients were alternatively assigned to the groups. TCI – Target control infusion; ISB – Interscalene brachial plexus block; N – Number of patients

pressure (NIBP), end tidal CO₂ and inhalational agent monitoring were done during the entire procedure. NIBP recording was done at 3 minutes intervals in the non-operative upper arm. With the patient in the lateral decubitus position, anaesthesia was maintained using either TCI propofol (target plasma concentration of 3 µg/ml, in TCI propofol group) or 1.2-1.5 Minimum Alveolar Concentration (MAC) of sevoflurane (Datum Vaporiser, MEDITEC England, Abbot Ltd, in sevoflurane group). Oxygen 33%, N₂O 67% mixture was used in both the groups. Age related iso-MAC sevoflurane concentrations were used to achieve the desired concentrations (0.8% (minimum)-2% (maximum), of expired concentrations) in the sevoflurane group. Muscle paralysis was achieved with bolus doses of inj.vecuronium, and controlled ventilation was carried out throughout the procedure. Systolic blood pressure (SBP), diastolic blood pressure (DBP), mean blood pressure (MBP) and heart rate were recorded every 3rd minute during the entire procedure. The surgical period was considered from the time of insertion of the arthroscope to its removal. Prior to insertion of the arthroscope, efforts were made to attain the target systolic pressure 20-25% below the baseline SBP using the following methods. Method A (anaesthetic depth increase) included administering additional doses of fentanyl (1-2 µg/kg) with or without propofol (1 mg/kg) or temporarily (for approximately 10 minutes) increasing the concentrations of sevoflurane (≥1.5 total MAC, 3.5%, maximum). Method B included pharmacological intervention using either a β-blocker (metoprolol, 3-5 mg or esmolol, 20 mg IV) or IV nitroglycerine boluses (25-50 µg). If target SBP was not achieved with the above methods within the next 10-12 minutes, infusion of nitroglycerine or sodium nitroprusside would be considered (Method C). Any adverse events like persistent hypotension (>2 readings of lower blood pressures than target or MAP <60 mm of Hg) or severe bradycardia (heart rate of <40 beats/minute) would be treated accordingly (saline bolus, inj. ephedrine, inj. atropine).

Initial pump pressure was 50 mm of Hg and flow at 50% was maintained throughout the procedure whenever visualisation was adequate. Any increased requirement in pump pressure and flow was noted. A 'red-out period' was considered when joint space visualisation was impossible owing to the excessive bleeding from bone or soft tissue. Such red-outs were recorded only during the on-going surgical process and not during insertion of the scope or with pump in the 'off' mode. The amount of saline irrigation fluid used (in litres) and the duration of surgery were noted. The

irrigation fluid return was analysed for haemoglobin (Hb). The measurable Hb of saline was quantified in both groups. At the end of the procedure, the visual score, grading the visibility of the joint space during surgery by the surgeon and anaesthesiologist separately, was documented (excellent=4, good=3, adequate=2, poor=1). Extreme care of the patient was taken during the procedure to avoid hypothermia, urinary bladder distension, position related injuries etc.

Data are presented as mean with standard deviation (SD) and 95% confidence intervals (CI). Statistical analysis was performed using MedCalc software (version 9.3.6.0, Belgium). Student *t* test was used for comparison of haemodynamic data and Chi-square test was used for visual score comparison.

RESULTS

The demographic characteristics with sex distribution, age, weight, duration of surgery and the variety of surgical procedures are detailed in Table 1. There were no significant differences between the groups with respect to patient characteristics, type of surgery performed or baseline vitals [Table 1].

The primary variable was the blood pressure and the highest mean values of SBP, DBP and MBP of the propofol group were significantly lower than those of the sevoflurane group ($P=0.002$, 0.038 and 0.006 respectively) though the lowest achieved mean values of DBP and MBP were not [Table 2]. Also, the mean of means of SBP as well as the MBP were significantly lower in the propofol group ($P=0.009$, 0.032 respectively, Table 3). However, there were no differences either in highest or lowest mean heart rates achieved and mean of mean heart rates recorded between the groups.

A higher number of patients in the sevoflurane group (65% versus 18% of propofol group) required either anaesthetic intervention, pharmacological

Table 1: Patients data

	TCI Propofol	Sevoflurane
Sex M/F	13/4	11/6
Age (years)	41.4±15.7 (33-49)	44.4±16.4 (36-52)
Weight (Kg)	69.4±13.3 (62-74)	69.2±13.8 (62-76)
Duration of surgery	49.4±12.6 (43-56)	51.6±14.6 (44-59)
Type of surgery		
Bankarts repair	6	5
Subacromial decompression and shoulder arthroscopy	10	11
Others	1	1

TCI – Target controlled infusion

manipulation or both to achieve the desired blood pressure. Accounting for the higher number of hypotensive episodes needing intervention in the propofol group, the total number of interventions was still higher among the sevoflurane group. Fentanyl

Table 2: Haemodynamic data. Values are mean±SD, (95% confidence intervals)

	TCI Propofol	Sevoflurane	P
SBP (mm of Hg)			
Base line	129.2±10.9 (124-135)	131.1±10.5 (126-136)	0.608
Highest	100.4±6.1 (97-103)	116.8±18.9 (107-126)	0.002
Lowest	81.9±5.3 (79-85)	88.2±8.9 (84-93)	0.017
DBP (mm of Hg)			
Base line	77.3±6.6 (74-81)	79.6±6.5 (76-83)	0.302
Highest	71.5±9.4 (67-76)	79.7±12.5 (73-86)	0.038
Lowest	48.2±6.6 (45-51)	52.6±8.2 (48-57)	0.095
MBP (mm of Hg)			
Base line	94.5±7.2 (91-98)	96.8±7.5 (93-101)	0.373
Highest	80.1±7.7 (76-84)	91.2±13.7 (84-98)	0.007
Lowest	61.7±6.4 (58-65)	66.1±7.2 (62-70)	0.069
Heart rate (Beats/minute)			
Base line	71.5±11.8 (65-78)	73.4±11.2 (68-79)	0.633
Highest	73.1±10.5 (68-79)	68.7±8.2 (64-73)	0.183
Lowest	57.6±7.2 (54-61)	54.6±7.4 (51-58)	0.24

TCI – Target controlled infusion; SBP – Systolic blood pressure; DBP – Diastolic blood pressure; MBP – Mean blood pressure

Table 3: Haemodynamic data* for the duration of the study. Values are mean±SD, (95% confidence intervals)

	TCI Propofol	Sevoflurane	P
SBP (mm of Hg)	91.7±4.7 (89-94)	100.2±11.8 (94-106)	0.01
DBP (mm of Hg)	60.1±6.7 (56-63)	65.3±9.8 (60-70)	0.08
MBP (mm of Hg)	70.6±5.5 (68-73)	76.9±10.3 (72-82)	0.033
Heart rate (Beats/minute)	63.2±7.2 (68-73)	60.5±5.7 (72-82)	0.234

*Mean±SD of mean heart rate and blood pressures. The F-Test of variance ratio test is used to compare the SDs of individual hemodynamic values; $P < 0.05$ for SBP, $P > 0.05$ for DBP, MBP and Heart rate; TCI – Target controlled infusion; SBP – Systolic blood pressure; DBP – Diastolic blood pressure; MBP – Mean blood pressure

Table 4: Anaesthetic/surgical factors; values absolute or mean±SD, (95% confidence intervals)

	TCI Propofol	Sevoflurane	P
Fentanyl consumption (µg)	138.2±41.6 (117-159)	163.2±48.51 (138-188)	
Interventions to achieve target BP			
a) Anaesthetic depth adjustment (method A)	3	11	
b) Pharmacological interventions (method B and C)	B=2, C=0	B=9, C=1	
c) Interventions to correct hypotension	7	4	
Total number of interventions (a+b+c)	12	25	
Total number of patients intervened (%)	6 (35)	13 (76)	
Saline used (Litres)	6.4±2.4 (4.8-7.4)	8.7±3.6 (6.8-10.6)	0.02
Hb characteristics			
Measurable (%)	7 (41)	14 (82)	
Visual analogue score			
VAS-Surgeon (excellent/good/adequate/poor)	15/1/1/0	10/6/1/0	<0001
VAS-Anaesthesiologist (excellent/good/adequate/poor)	13/4/0/0	11/4/2/0	<001
Red-outs (%)	0 (0)	1 (6)	
Number of patients with requests for increased pump pressure and flow (%)	0 (0)	6 (35)	

TCI – Target controlled infusion; BP – Blood pressure; Hb – Haemoglobin; VAS – Visual analogue score

consumption was higher in the sevoflurane group, though they did not differ statistically. The volume of saline irrigant consumed was significantly higher in the sevoflurane group ($P=0.02$). Hb of the saline irrigation return was measurable in a higher number of patients in the sevoflurane group (81% of sevoflurane group (maximum, 0.4 gm/dl) versus 41% of patients belonging to propofol group (maximum, 0.1 gm/dl)). Better visual scores by both the surgeon and the anaesthesiologist were recorded in the propofol group ($P < 0.001$). One (6%) incidence of red-out was observed in a sevoflurane group patient. Intra-operatively, the surgeon requested an increase of pump pressure and flow in 35% of the sevoflurane group patients for better visualisation of joint space (none in the propofol group), [Table 4].

No immediate perioperative surgical or anaesthetic complications were noted.

DISCUSSION

Reduction of SBP or MBP (20-25% of baseline in a normotensive individual) decreases bleeding from joint bones and improves visualisation during shoulder arthroscopic surgery.^[6] Abolition of painful stimuli employing the inter-scalene block, supplements the hypotensive effect of sufficiently deep anaesthesia. All our patients had complete inter-scalene block, were deeply anaesthetised and maintained using intravenous propofol or sevoflurane with adequate but pre-defined concentrations. N_2O was used in both groups. Total intravenous anaesthesia constitutes nearly 25% of all anaesthetic administrations in today's world and TCI propofol is well described for a variety of surgeries or procedures at different doses.^[7,8] Vincent and colleagues

used TCI propofol for sedation in patients undergoing shoulder arthroscopic surgery under regional anaesthesia at target plasma concentrations of 0.8-0.9 µg/ml.^[4] When TCI propofol is used alone, a plasma concentration of 4-6 µg/ml is necessary to maintain the necessary depth of anaesthesia in ASA 1 patients. The concomitant use of N₂O reduces this requirement to as low as 2.5 µg/ml.^[9] A combination of 67% nitrous oxide and fentanyl reduces the EC₅₀ (the effective concentration at which 50% of patients do not respond to a painful stimulus) by approximately 30%, akin to iso-MAC values for inhalational anaesthetics.^[10,11] Considering these factors, a target plasma concentration of 3 µg/ml has been used in our patients.

Propofol used alone or in combination with fentanyl demonstrates profound hypotensive effect in patients with abolished pain signals.^[12] During maintenance of anaesthesia with an infusion, SBP is decreased to 20-30% of pre-induction levels. Propofol infusion at 100 µg/kg/min results in a significant decrease in systemic vascular resistance (SVR) without altering the cardiac or the stroke index. But infusion of lower doses of propofol (54-100 µg/kg/min) with concomitant use of narcotics and N₂O, selectively reduces cardiac output and stroke volume without altering SVR.^[13,14] These cardiovascular effects of propofol greatly favored the achievement of target blood pressures in our patients. A synergistic role of the regional anaesthetic drugs in potentiating these effects cannot however be ruled out. The higher incidence of hypotension episodes needing intervention in the propofol group seems to be a direct reflection of its more profound hypotensive effects.

Like propofol, sevoflurane too depresses the intrinsic inotropic state in isolated myocardium and this action plays an important role in determining the haemodynamic effects of this volatile agent in humans, with or without heart disease.^[15] In animals, sevoflurane decreases myocardial contractile function to approximately 40-45% of control values only at ≥1.75 MAC in the presence or absence of autonomic nervous system tone.^[16] We have used iso-MAC values of sevoflurane and at 1-1.5, the myocardial depression induced is lower, but associated with a definite reduction in MBP. Though it is arguable that the use of iso-MAC values of sevoflurane does not induce hypotension equivalent to that of 1.75 MAC, efforts were made to deepen the anaesthesia using 1.5 MAC sevoflurane, prior to a pharmacological intervention in our patients. A higher number of anaesthetic interventions to achieve target SBP as well as the larger SDs* in the sevoflurane group

possibly indicate an inconsistency and non-uniformity in the cardiovascular actions of the inhalational agent as compared to propofol. Interestingly, heart rates did not vary between the groups though mean heart rates remained much lower than baseline values. These effects were explained by the action of propofol on the baroreflex and cardiac parasympathetic tone, previously.^[17,18] But for the significantly larger number of pharmacological interventions in the sevoflurane group, we believe, heart rates would have been higher in this group as compared to the group receiving propofol.

Lower visual scores, linked to bleeding within the joint space during arthroscopy, are best correlated with Hb measurement of the saline irrigation return. Considering the massive dilutional factor, importance accorded to the actual quantification of Hb levels is questionable. Estimation of bleeding within the joint space during arthroscopy has been attempted by various authors,^[19] using a product of irrigant fluid and Hb measurements. The sensitivity of our methodology for Hb estimation resulted in a 'non-measurable' Hb concentration in several patients. The number of patients with 'measurable' Hb, which we considered therefore as a relevant factor signifying bleeding into the joint space correlated well with the comparative fall in blood pressures observed between the two groups. Morrison and colleagues,^[20] explain the relationship between the blood pressure and visual clarity during shoulder arthroscopy. Extravasation of fluid into the periarticular tissues can occur, giving rise to what is described as the 'football shoulder' and such an occurrence could result in a 'vicious cyclic' event (venous congestion-intra-articular bleed-demand for increased pump pressure and flow-further extravasation) leading to a self-perpetuating venous ooze that hampers vision. As we believe, the fluid ingress into the chest wall, neck, and supra-scapular regions, which are outside the area covered by the inter-scalene block, may provoke intense pain signals that accentuate blood pressures and promote further haemorrhage. We observed higher demands for increased pressure, irrigant flow and consequently an increased saline consumption in the sevoflurane group patients despite similar durations of surgery within the two groups. It is however possible that joint-specific factors like fibrosis, inflammation and other operating room circumstances could affect the duration of surgery and quantity of saline used, and a particular anaesthetic technique alone cannot be the sole factor taken into account to explain our observations. The only incident of 'red out' was a possible venous bleed,

managed by gentle external compression and probably unrelated to haemodynamics of the individual.

The well described variability that exists with the use of the calibrated vaporizer can be associated, though to a less degree with target controlled drug delivery too.^[21] However, in patients with complete inter-scalene regional blockade, factors like operating time, surgical stress and variability in individual pain responses do not mandate vigilant titration of intravenous propofol by the anaesthesiologist.^[21] Besides, the proven advantages of the TCI pump with respect to rapidity of induction and recovery, stable maintenance, fewer post-operative adverse effects and earlier discharge from the post-anaesthesia care unit,^[21,22] lend additional support to our results favoring the technique.

CONCLUSION

TCI propofol appears to be superior to sevoflurane anaesthesia in inter-scalene blocked patients undergoing shoulder arthroscopy both as regards the efficacy as well as the convenience of maintaining low BP during surgery. Directly, it seems to be associated with less intra-articular bleeding and improved visualisation during the procedure. Indirectly, it reduces interventions by the anaesthesiologist and minimizes requests by the surgeon to manipulate the pump settings. The acclaimed advantages of TCI pump over the vaporizer may further support the use of TCI propofol anaesthesia for shoulder arthroscopic procedures.

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