Original Article

Effects of irrigation fluid in shoulder arthroscopy

Address for correspondence:
Dr. Surbhi Gupta,
Department of Anaesthesiology and Critical Care, St. John's Medical College and Hospital, Johnnagara, Koramangala, Bangalore - 560 034, Karnataka, India.
E-mail: surbhi_pg@yahoo.com

Surbhi Gupta, M Manjuladevi, KS Vasudeva Upadhyaya, AM Kutappa, Rajkumar Amaravathi, J Arpana

Department of Anaesthesiology and Critical Care, St. John's Medical College and Hospital, Johnnagara, Koramangala, Bangalore, Karnataka, India

ABSTRACT

Background and Aims: Extravasation of irrigation fluid used in shoulder arthroscopy can lead to life-threatening airway and systemic complications. This study was conducted to assess the effect of irrigation fluid absorption on measurable anthropometric parameters and to identify whether these parameters predict airway/respiratory compromise. **Methods:** Thirty six American Society of Anaesthesiologists physical status one or two patients aged 15–60 years undergoing shoulder arthroscopy under general anaesthesia were recruited. Measured variables preoperatively (baseline) and at the end of surgery were neck, chest, midarm and midthigh circumferences, weight, haemoglobin and serum sodium. Temperature, endotracheal tube cuff pressure, airway pressure, duration of surgery, amount of irrigation fluid and intravenous fluid used were also noted. Measured parameters were correlated with the duration of surgery and the amount of irrigation fluid used. **Results:** Postoperatively, the changes in variables showed a significant increase in the mean values (cm) for neck, chest, midarm and midthigh circumference (mean ± standard deviation: 2.35 ± 1.9, $P < 0.001$; 2.9 ± 3.88 cm, $P < 0.001$; 3.28 ± 2.44, $P < 0.001$ and 0.39 ± 0.71, $P = 0.002$, respectively) and weight (kg) (1.17 ± 1.24, $P < 0.001$). The post-operative haemoglobin (g/dL) levels decreased significantly (0.89 ± 1.23, $P < 0.001$) as compared to the baseline. No significant change was found in the serum sodium levels ($P = 0.92$). No patient experienced airway/respiratory compromise. **Conclusion:** Regional and systemic absorption of irrigation fluid in arthroscopic shoulder surgery is reflected in the degree of change in the measured anthropometric variables. However, this change was not significant enough to cause airway/respiratory compromise.

Key words: Adverse effects, airway obstruction, arthroscopy, irrigation fluid, post-operative complications, shoulder joint

Access this article online
Website: www.ijaweb.org
DOI: 10.4103/0019-5049.177866
Quick response code

INTRODUCTION

Shoulder arthroscopy is a minimally invasive procedure performed for various diagnostic and therapeutic purposes. Irrigation fluid under pressure is used to distend the joint space and enhance visualisation. This fluid has the potential to migrate into adjacent soft tissues and systemic circulation leading to complications.

Cases with extravasation of irrigation fluid leading to airway oedema and tracheal compression have been reported.[1-4] Risk factors associated with the extravasation of irrigation fluid and its complications are protracted duration of the surgical procedure, increased arthroscopic pump pressure and flow rate, use of excessive amount of irrigation fluid, procedures involving the sub-acromial space (potential space with no encapsulation), lateral decubitus position and obesity.[5] However, there is paucity of clinical studies that measure the change in anthropometric parameters and that can predict airway and/or

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How to cite this article: Gupta S, Manjuladevi M, Vasudeva Upadhyaya KS, Kutappa AM, Amaravathi R, Arpana J. Effects of irrigation fluid in shoulder arthroscopy. Indian J Anaesth 2016;60:194-8.

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respiratory compromise in patients undergoing shoulder arthroscopy. The primary objective of this study was to assess the effect of irrigation fluid absorption on measurable anthropometric parameters and the secondary objective was to identify whether these parameters predict airway and/or respiratory compromise.

METHODS

This prospective observational study was undertaken after Institutional Ethics Committee's approval and written informed consent from the participating patients. Thirty six patients with American Society of Anaesthesiologists (ASA) physical status grade one or two, aged 15–60 years undergoing shoulder arthroscopy under general anaesthesia were included. Patients with respiratory disease, traumatic or difficult intubation, renal disease, pregnancy and obesity were excluded. Sample size of 36 was estimated based on a study done by Smith and Shah, assuming a correlation of 0.84 between the change in anthropometric measures and the amount of fluid used, with 5% level of significance and 80% power.[6]

General anaesthesia was induced with intravenous (IV) propofol 2 mg/kg, fentanyl 2 μg/kg and atracurium 0.5 mg/kg. Airway was secured with an appropriate size-cuffed endotracheal tube. Anaesthesia was maintained with oxygen, air, isoflurane and atracurium. All patients were positioned in the lateral decubitus position with operative arm in 30–45° abduction and forward flexion.

Patients were monitored with electrocardiograph, non-invasive blood pressure, pulse oximeter (SpO_2) and capnograph ($ETCO_2$). The temperature, endotracheal tube cuff pressure (ETTc) and airway pressure (Paw) were also measured. These parameters were recorded every 15 min for the first 2 h and every 30 min thereafter. The measured variables preoperatively (baseline) and at the end of surgery were neck, chest, midarm and midthigh circumferences (cm), weight (kg), haemoglobin (g/dL) and serum sodium (meq/L).

The neck circumference was measured at the level of the thyroid cartilage, chest circumference at the level of axilla in the supine position, midarm circumference between acromion and olecranon, midthigh circumference between greater trochanter and lateral femoral condyle. The pre-operative weight of the patient was measured on the morning of surgery and the post-operative weight was measured on the same weighing scale 1 h post–surgery, once the patient was shifted to the ward.

Normal saline was used as irrigation fluid and two to four portals were used for the procedure. The irrigation fluid pump pressure and flow rate were standardised in the normal recommended range of 40–80 mmHg and 50–150 mL/min, respectively. Duration of surgery, amount of irrigation fluid and IV fluid used were noted. Post-surgery, endotracheal tube cuff leak test was performed and neuromuscular block was antagonised with IV neostigmine 50 μg/kg and glycopyrrolate 10 μg/kg. After adequate reversal, trachea was extubated. Subjective feeling of breathlessness, tightness in neck and chest, inability to phonate, stridor, chest retractions, increase in respiratory rate (>20 breaths per minute), cyanosis and decrease in SpO_2 (<90%) were used as indicators of airway/respiratory compromise.

Descriptive statistics was reported using mean and standard deviation. Pre-operative and post-operative measured parameters were analysed using paired *t*-test. Correlation between the variables was assessed using Spearman's rank correlation test. $P < 0.05$ was considered statistically significant. Statistical analysis was done using SPSS version 18 (SPSS Inc, Chicago, Illinois, USA).

RESULTS

Thirty six ASA grade one or two patients were enrolled in the study, out of which 37.5% (12 patients) were females. The mean age of the patients was 47.7 ± 11.4 years. Table 1 shows the comparison of Pre-operative and post-operative measured parameters. There was a significant increase in the mean values for neck, chest, midarm, midthigh circumferences and weight. The post-operative haemoglobin levels decreased significantly. No significant change was found in the serum sodium levels. Mean changes in haemoglobin, sodium and anthropometric measurements are depicted in Table 2. Table 3 shows correlation between the changes in measured parameters with the amount of irrigation fluid used and duration of surgery. Significant correlation was observed between the change in neck circumference and weight gain with the amount of irrigation fluid used and the duration of surgery. No patient experienced airway/respiratory compromise. There was a general trend of decrease in body temperature [$P = 0.001$, Figure 1] and increase in

Table 1: Comparison of pre-operative and post-operative measurements

Measured variable	Pre-operative (*n*=36)	Post-operative (*n*=36)	*P*
Haemoglobin (g/dL)	14.2±1.7	13.3±1.8	<0.001
Neck circumference (cm)	36.8±5.3	39.1±5.5	<0.001
Chest circumference (cm)	95.3±7.8	98.3±8.2	<0.001
Midarm circumference (cm)	29.3±3.1	32.5±3.1	<0.001
Midthigh circumference (cm)	49.2±7.8	49.5±7.8	0.002
Weight (kg)	67.9±11.5	69.1±11.5	<0.001
Serum sodium (mEq/L)	136.6±2.1	136.7±3.6	0.92

Reported as mean±standard deviation

Table 2: Changes in haemoglobin and anthropometric measurements

Measured variable	Minimum	Maximum	Mean±SD
Change in haemoglobin (g/dL)	−4.1	1.3	−0.89±1.23
Change in neck circumference (cm)	0	6.5	2.35±1.90
Change in chest circumference (cm)	0	18	2.90±3.88
Change in midarm circumference (cm)	0	10	3.28±2.44
Change in midthigh circumference (cm)	0	2.5	0.39±0.71
Change in weight (kg)	0	5	1.17±1.24
Amount of fluid used (L)	5	52	24.63±13.45
Duration of surgery (min)	60	390	189.17±85.63

Change – Post-operative-pre-operative; SD – Standard deviation

Table 3: Correlation between the changes in measured parameters with the amount of irrigation fluid used and duration of surgery

Measured variable	Amount of irrigation fluid used (*r*)	Duration of surgery (*r*)
Change in haemoglobin	−0.31	−0.02
Change in neck circumference	0.65*	0.55*
Change in weight	0.46*	0.37*
Change in midarm circumference	0.09	0.26
Change in midthigh circumference	0.24	0.21
Change in chest circumference	0.23	-0.08

*$P<0.05$; *r* – Correlation

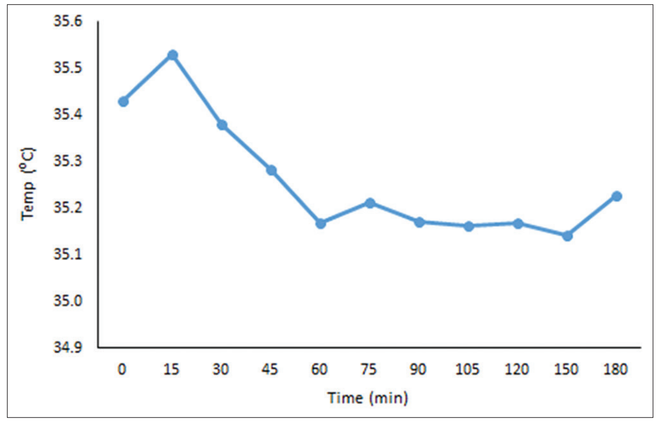

Figure 1: Change in body temperature (°C) with time (min)

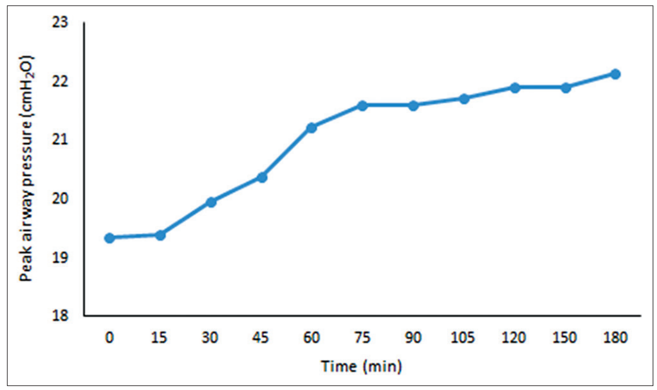

Figure 2: Change in peak airway pressure (cmH_2O) with time (min)

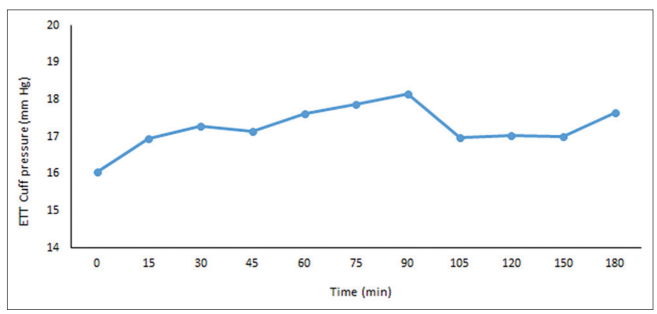

Figure 3: Change in endotracheal cuff pressure (mmHg) with time (min)

airway pressure [$P = 0.02$, Figure 2] with time, which were statistically significant. The change in ETTc was not significant [$P = 0.61$, Figure 3].

DISCUSSION

The irrigation fluid used in shoulder arthroscopy can extravasate into adjoining soft tissues and lead to tracheal compression. Life-threatening airway compromise related to the excess use of irrigation fluid is well-documented.[7-9] Literature describes cases where patients developed facial and neck oedema, laryngeal oedema and extensive swelling across the chest, during shoulder arthroscopy under general/regional anaesthesia.[10-13] The patients had to be re-intubated and mechanically ventilated postoperatively. We reported three cases from our institution where patients had to be re-intubated, electively ventilated and monitored in the Intensive Care Unit following shoulder arthroscopy.[4] Various means of measuring this tracheal compression have been suggested such as measurement of neck circumference (pre-operative and post-operative), monitoring airway pressures/compliances, absence of cuff leak with endotracheal cuff deflation, airway oedema on direct laryngoscopy/fibreoptic bronchoscopy, ultrasound observation of tissue fluid infiltration and soft tissue enlargement on chest and lateral cervical X-ray.[4,13-15]

We found a significant increase in patient's neck, chest, midarm and midthigh circumferences [Tables 1 and 2] indicating regional and systemic absorption of irrigation fluid. The increase in neck circumference had a positive correlation with the amount of irrigation fluid used and the duration of surgery [Table 3]. An increase of up to 5 cm in neck circumference after routine shoulder arthroscopies has been reported.[16] A difference of 14 cm in the neck circumference was observed in one study.[17] In another study, authors suggested to look for airway compromise when the neck circumference increased beyond 4 cm.[17,18] The maximum increase in neck circumference which we found in one of our patients was 6.5 cm. The amount of extravasated irrigation fluid could have been limited as we had standardised the arthroscopic pump pressure (40–80 mmHg) and flow rate (50–150 mL/min). Therefore, the increase in neck and chest circumference in our patients did not pose any airway problems postoperatively.

In our study, statistically significant increase in airway pressure ($P = 0.02$) was observed which could be attributed to systemic absorption of irrigation fluid. Soft tissue oedema of the neck from the extravasated irrigation fluid can lead to a significant increase in plateau airway pressure and cuff pressure.[14] The change in ETTc in our study, which was measured using a pressure transducer (Edwards kit: Edwards Life Sciences LLC, USA), was not significant ($P = 0.61$). Thus, monitoring the ETTc and airway pressure may lead to a clinical suspicion of airway oedema.

A cuff leak test is used to assess the presence or absence of an air leak around the tube to warn for the presence of upper airway oedema.[19,20] Cuff leak can be calculated by the difference between the expired tidal volume with the endotracheal tube cuff inflated and deflated. A cuff leak of more than 110 mL (negative cuff leak test) has been reported to be associated with less chances of post-extubation stridor.[20] The incidence of positive leak tests (cuff leak <110 mL) at the end of surgery was found to be significantly higher in patients undergoing shoulder arthroscopy than patients undergoing fixation of clavicle or humerus fractures (47% vs. 17%, $P = 0.010$). Authors related this to the adverse effect of extravasated irrigation fluid in shoulder arthroscopy.[14] In our study, the endotracheal cuff leak test was negative (cuff leak present) in all patients and therefore we extubated all our patients immediately after the completion of surgery.

Haemodilution and increase in thigh circumference may be considered as indicators of systemic fluid absorption. A drop in haemoglobin of 0.89 ± 1.23 g/dL was observed in our patients. There was a positive correlation between the drop in haemoglobin with the duration of surgery and the amount of irrigation fluid used [Table 3]. A drop in haemoglobin of 0.6 g/dL ($P < 0.0001$) was observed in a study on shoulder arthroscopy and authors attributed it to the dilutional effect caused by irrigation fluid.[6] Awareness of this haemodilution may help in avoiding unnecessary blood transfusion in these patients.

Sodium chloride was used as irrigation fluid and the same can be attributed to the maintenance of normal serum sodium levels in our study. Use of excess irrigation solutions other than normal saline (Glycine, lactated Ringer's solution) may result in acid base and electrolyte imbalance which may be harmful to the patients.

There may be weight gain with the accumulation of irrigation fluid in soft tissues. In our study, we observed a mean weight gain of 1.17 ± 1.24 kg, which had a significant correlation with the mean duration of surgery (189.17 ± 85.63 min, $r = 0.37$) and amount of irrigation fluid used (24.63 ± 13.45 L, $r = 0.46$). A mean weight gain of 0.9 kg ($P < 0.0001$) was observed which had a strong correlation with the amount of fluid used.[6] Another study found a weight gain of 1.9 ± 1.7 kg with the use of 30 ± 24 L of irrigation fluid.[21] Weight gain may indicate excessive retention of irrigation fluid. This may not be tolerated by patients who are elderly and/or with cardiac and renal compromise.

Warming of irrigation fluid prevents decrease in core body temperature. A change in body temperature can occur more often in patients undergoing shoulder arthroscopic surgeries with room temperature irrigation fluid than with warm irrigation fluid.[22] In our study, there was a significant fall in the core body temperature ($P = 0.001$) despite the use of a warming blanket and a fluid warmer for IV fluids. The decrease in body temperature with resultant increase in oxygen demand postoperatively can aggravate respiratory compromise in a patient with airway obstruction.

Recent attention has focussed on awareness among the operating team personnel about the impact of pump pressure and flow rate, amount of irrigation fluid and duration of surgery, which are modifiable factors to prevent such complications.[15] Easily measurable anthropometric parameters (neck, chest, midarm, midthigh circumference and weight), ETTc and airway pressure may alert the operating team for any airway or systemic complications.

CONCLUSION

Regional and systemic absorption of irrigation fluid in arthroscopic shoulder surgery is reflected in the degree of change in the anthropometric variables and haemoglobin. However, this change in anthropometric measurements was not significant enough to cause airway/respiratory compromise.

Financial support and sponsorship

Nil.

Conflicts of interest

There are no conflicts of interest.

REFERENCES

1. Jirativanont T, Tritrakarn TD. Upper airway obstruction following arthroscopic rotator cuff repair due to excess irrigation fluid. Anaesth Intensive Care 2010;38:957-8.
2. Saeki N, Kawamoto M. Tracheal obstruction caused by fluid extravasation during shoulder arthroscopy. Anaesth Intensive Care 2011;39:317-8.
3. Borgeat A, Bird P, Ekatodramis G, Dumont C. Tracheal compression caused by periarticular fluid accumulation: A rare complication of shoulder surgery. J Shoulder Elbow Surg 2000;9:443-5.
4. Manjuladevi M, Gupta S, Upadhyaya KV, Kutappa AM. Postoperative airway compromise in shoulder arthroscopy: A case series. Indian J Anaesth 2013;57:52-5.
5. Antonucci S, Orlandi P, Mattei PA, Amato F. Airway obstruction during arthroscopic shoulder surgery: Anesthesia for the patient or for the surgeon? Minerva Anestesiol 2006;72:995-1000.
6. Smith CD, Shah MM. Fluid gain during routine shoulder arthroscopy. J Shoulder Elbow Surg 2008;17:415-7.
7. Orebaugh SL. Life-threatening airway edema resulting from prolonged shoulder arthroscopy. Anesthesiology 2003;99:1456-8.
8. Yoshimura E, Yano T, Ichinose K, Ushijima K. Airway obstruction involving a laryngeal mask airway during arthroscopic shoulder surgery. J Anesth 2005;19:325-7.
9. Blumenthal S, Nadig M, Gerber C, Borgeat A. Severe airway obstruction during arthroscopic shoulder surgery. Anesthesiology 2003;99:1455-6.
10. Sharma M, Achar SK. Airway oedema during shoulder arthroscopy: How we played it safe! Indian J Anaesth 2013;57:319-20.
11. Khan F, Padmanabha S, Shantaram M, Aravind M. Airway compromise due to irrigation fluid extravasation following shoulder arthroscopy. J Anaesthesiol Clin Pharmacol 2013;29:578-9.
12. Ozhan MO, Suzer MA, Cekmen N, Caparlar CO, Eskin MB. Tracheal compression during shoulder arthroscopy in the beach-chair position. Curr Ther Res Clin Exp 2010;71:408-15.
13. Errando CL. Ultrasound observation of tissue fluid infiltration causing stridor in a woman undergoing shoulder arthroscopy. Rev Esp Anestesiol Reanim 2011;58:582-4.
14. Gwak MS, Kim WH, Choi SJ, Lee JJ, Ko JS, Kim GS, *et al.* Arthroscopic shoulder surgery under general anesthesia with brachial plexus block: Postoperative respiratory dysfunction of combined obstructive and restrictive pathology. Anaesthesist 2013;62:113-20.
15. Bhaskar SB, Manjuladevi M. Shoulder arthroscopy and complications: Can we afford to relax? Indian J Anaesth 2015;59:335-7.
16. Hynson JM, Tung A, Guevara JE, Katz JA, Glick JM, Shapiro WA. Complete airway obstruction during arthroscopic shoulder surgery. Anesth Analg 1993;76:875-8.
17. Gogia AR, Bajaj J, Sahni A, Saigal D. Negative-pressure pulmonary oedema in a patient undergoing shoulder arthroscopy. Indian J Anaesth 2012;56:62-5.
18. Chellam S, Chiplonkar S, Pathak K. Change in neck circumference after shoulder arthroscopy: An observational study. Indian J Anaesth 2015;59:365-8.
19. Ochoa ME, Marín Mdel C, Frutos-Vivar F, Gordo F, Latour-Pérez J, Calvo E, *et al.* Cuff-leak test for the diagnosis of upper airway obstruction in adults: A systematic review and meta-analysis. Intensive Care Med 2009;35:1171-9.
20. Miller RL, Cole RP. Association between reduced cuff leak volume and postextubation stridor. Chest 1996;110:1035-40.
21. Lo IK, Burkhart SS. Immediate postoperative fluid retention and weight gain after shoulder arthroscopy. Arthroscopy 2005;21:605-10.
22. Kim YS, Lee JY, Yang SC, Song JH, Koh HS, Park WK. Comparative study of the influence of room-temperature and warmed fluid irrigation on body temperature in arthroscopic shoulder surgery. Arthroscopy 2009;25:24-9.

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