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ORIGINAL STUDY

Surrounding soft tissue pressure during shoulder arthroscopy

Jeroen De Wachter, Francis Van Glabbeek, Roger van Riet, Wim Van Leemput, Karel Vermeyen, Johan Somville

From the University Hospital of Antwerp, Edegem, Belgium

In 40 patients undergoing arthroscopic subacromial decompression, we monitored the soft tissue pressure in the paratracheal region and in the deltoid and supraspinatus muscles, looking for evidence of a potentially dangerous rise in pressure, especially in the paratracheal region. Statistical analysis was used to determine predictable variables of the time of reaching maximum pressure in and between the three regions.

Deltoid pressure rose quickly during surgery, and did not drop to baseline levels at the end of surgery. Supraspinatus pressures showed a similar trend but with lower maximum levels of pressure rise. Five patients had an (unexpected) rise in paratracheal pressure, with an absolute maximum of 133.4 mmHg in one. In only two patients, did "10 minutes post-op" paratracheal pressure levels not drop to baseline levels. No respiratory problems occurred during any procedure.

There are no variables to predict a potentially dangerous rise in surrounding soft tissue pressure during shoulder arthroscopy. We recommend endotracheal intubation during shoulder arthroscopy.

Keywords : shoulder ; arthroscopy ; soft tissue ; pressure.

INTRODUCTION

Arthroscopic subacromial decompression (with or without arthroscopic resection of the distal clavicle) has become a routine procedure in orthopaedic shoulder surgery (*4*).

The complication rate in arthroscopic shoulder surgery is reported to range from 0.76% to 10.6%. Neurapraxia of the plexus brachialis, intraoperative bleeding, excessive extravasation of fluid and infection are the most commonly encountered complications (*1, 2, 10, 11*). The musculocutaneous nerve and the lateral femorocutaneous nerve are the nerves most at risk, especially when performing the procedure in lateral decubitus.

Other complications of shoulder arthroscopy include articular cartilage damage during instrumentation, reflex sympathetic dystrophy, failure of the procedure (e.g. recurrence of instability, undercorrection of acromial spur, …), instrument failure and iatrogenic rotator cuff tear caused by insertion of instruments through the posterior portal (*2, 10*). Airway related complications include (complete) airway obstruction, pleural puncture, subcutaneous

■ Jeroen De Wachter, MD, Resident.
■ Francis Van Glabbeek, MD, PhD, Orthopaedic Surgeon.
■ Roger Van Riet, MD, PhD, Resident.
■ Wim Van Leemput, MD, Resident.
■ Karel Vermeyen, MD, PhD, Professor and Chairman of Anaesthesia.
■ Johan Somville, MD, PhD, Professor and Chairman of Orthopaedic Surgery.
Correspondence : Francis Van Glabbeek, Department of Orthopaedic Surgery University Hospital Antwerp, Wilrijkstraat 10, B-2650 Edegem, Belgium.
E-mail : francis.van.glabbeek@uza.be.

emphysema, pneumothorax and pneumomediastinum (*3, 5-7*).

General anaesthesia (cardiac arrhythmias, pneumonia, aspiration pneumonitis) or regional anaesthesia (superficial infections, seizures) may give rise to complications as well.

Extravasation of fluid into the surrounding soft tissues can be a potentially life-threatening event, owing to airway compression and tracheal shift. This is especially true in patients who undergo shoulder arthroscopy under loco-regional anaesthesia and therefore are not intubated. Airway obstruction during arthroscopic shoulder surgery has previously been reported (*5*).

Another potential concern in arthroscopic surgery of the shoulder is that, intra- and postoperatively, intramuscular pressures can rise to a dangerously high level, possibly leading to a compartment syndrome of the shoulder (*9*). Lee *et al* (*8*) found that intra-operative pressures in the deltoid muscle were greater than the assumed levels for compartment syndrome, but as these pressures were sustained only for a short period of time and dropped to nearly baseline levels soon after the end of the procedure , no harm was noted in the long run.

The aim of this study was to monitor the evolution of the pressures in the deltoid and supraspinatus muscle and in the paratracheal region during arthroscopic subacromial decompression.

MATERIAL AND METHODS

We performed a prospective study in 40 patients, including 20 male and 20 female patients. A written informed consent was obtained for all. The average age was 51 years (range : 31 to 71). The average Body Mass Index was 25.8 +/- 3.6 kg/m^2 (range : 19.9 to 35.1). All patients presented with signs of longstanding rotator cuff disease, with clinical examination tests clearly positive for subacromial impingement syndrome. Conservative treatment was attempted in all patients for a period of at least six months, prior to surgery. Conservative treatment consisted of physiotherapy, anti-inflammatory drugs and subacromial steroid injections.

Standard radiographs of the shoulder were taken (AP in neutral and external rotation, and outlet view) and inspected for signs of chronic rotator cuff disease (acromial spur, cranial migration of humeral head, glenohumeral arthritis, AC joint arthritis, intratendinous calcifications).

Ultrasonography of the shoulder was performed by a single experienced radiologist to assess for signs of impingement and evaluation of the rotator cuff condition.

Patients with advanced arthritis of the glenohumeral joint, as well as patients with full thickness rotator cuff tears as shown by ultrasonography or during the arthroscopic procedure, were excluded from this study.

All patients were intubated under general anaesthesia and positioned in the lateral decubitus position. The affected arm was suspended by skin traction (3 to 6 kg) in 20° abduction-elevation, taking care not to overstretch the arm. The shoulder was draped free and anatomical landmarks were marked with a marking pen.

We then inserted 21G needles (Terumo, Leuven, Belgium) in standard locations into the deltoid muscle, into the supraspinatus muscle and into the paratracheal region.

For the deltoid muscle the needle was inserted five centimeters distal to the lateral edge of the acromion. For the supraspinatus muscle the needle was inserted three centimetres medial from the lateral corner of the fossa supraspinata (fig 1). For the paratracheal region, the needle was inserted just medial to the sternocleidomastoid muscle, two centimeters above the incisura jugularis (fig 2). Before insertion, the needles were bent 30°, so that they could be taped to the skin after insertion. We took care that the deltoid and supraspinatus needles were kept intramuscularly, and that no disconnection of the lines occurred during the procedure.

The needles were connected to a saline solution filled line that was connected to a Datex-Ohmeda patient monitor. S/5 collect software (Helsinki, Finland) was used to collect data. Before inserting the needles, pressures were calibrated to zero mmHg at the level of insertion for each of the three measuring points separately.

A standard shoulder arthroscopy was performed, using a postero-lateral and a postero-medial portal. We did not use an outflow cannula. If necessary, a third anterior portal was made for resection of the lateral clavicle in case of AC joint arthritis. During the procedure, distension of the joint was obtained by pressurised saline bags (calibrated range 150-300 mmHg). After inspection of the glenohumeral joint, subacromial debridement and decompression was performed, using motorised burrs.

Systolic and diastolic blood pressures were recorded at the start of the procedure.

Pressure data were recorded every 30 seconds from the start of the procedure, until ten minutes after the

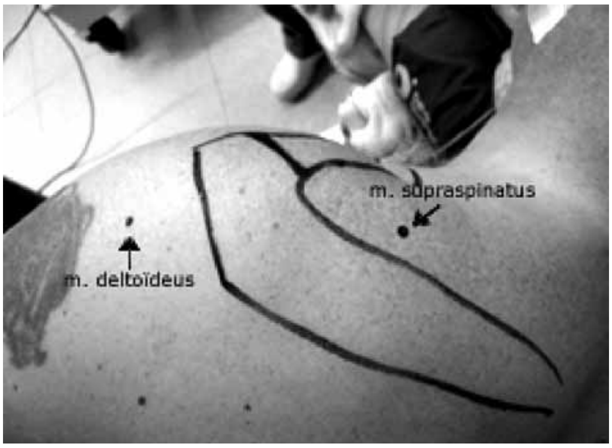


Fig. 1. — Insertion landmarks for deltoid and supraspinatus needles.

Fig. 2. — Insertion landmarks for paratracheal needle

fluid irrigation had stopped. Data were normalised to base levels for each patient and the evolution of the pressure was analysed, using 32-bit Labview software (Austin, TX, USA).

Statistical analysis was performed with the SPSS software package. Multiple Linear Regression was used to obtain the determinating variables for the time to reach the maximal pressure in the three regions. Analysis of co-variance looked for the influence of co-variants in the relationship of the time to reach maximum pressure between the three regions. A Spearman correlation test was used for correlations of time to reach maximal pressure between the three regions.

RESULTS

Average duration of surgery was 24 minutes (range : 9 min 30 sec to 49 min 30 sec).

No complications occurred. In all patients, blood pressures stayed within normal levels during the procedure. In 22 of the 40 patients, only a subacromial decompression was performed. In the remaining 18 patients, a lateral clavicular resection was performed additionally. All patients were discharged from hospital the day after surgery. Average peak pressure and maximum pressure during the procedure, as well as the pressure at ten minutes after the procedure are shown in table I and II.

Deltoid muscle pressure

The average peak pressure in the deltoid muscle was 98.14 +/- 58.17 mmHg (range : 19.08 to 262.37) during the procedure. The evolution of the pressure showed a steep rise during the first 10 minutes of the procedure, followed by a plateau of submaximal pressure. Twelve out of 40 patients reached a peak pressure of more than 200 mmHg, with one patient reaching an absolute maximum pressure of 262.40 mmHg. On average at ten minutes after the surgery, pressures had not dropped to baseline levels. The average pressure at ten minutes post-operatively was 9.92 +/- 19.36 mmHg (range : -54.19 to 51.02).

Supraspinatus muscle pressure

The average peak pressure in the supraspinatus muscle was 49.07 +/- 41.93 mmHg (range : 0.41 to 162.57) during the procedure. A similar trend in the evolution of the pressure was found, reaching its maximum at approximately ten minutes after the start of the irrigation inflow. Twelve out of 40 patients had a peak pressure of more than 100 mmHg, with an absolute maximum of 162.60 mmHg in one. Ten minutes post-surgery, average pressure was 9.09 +/- 10.97 mmHg (range : -15.70 to 35.23).

Table I. — Average peak pressure and maximum pressure in the three investigated regions during the 40 arthroscopic procedures

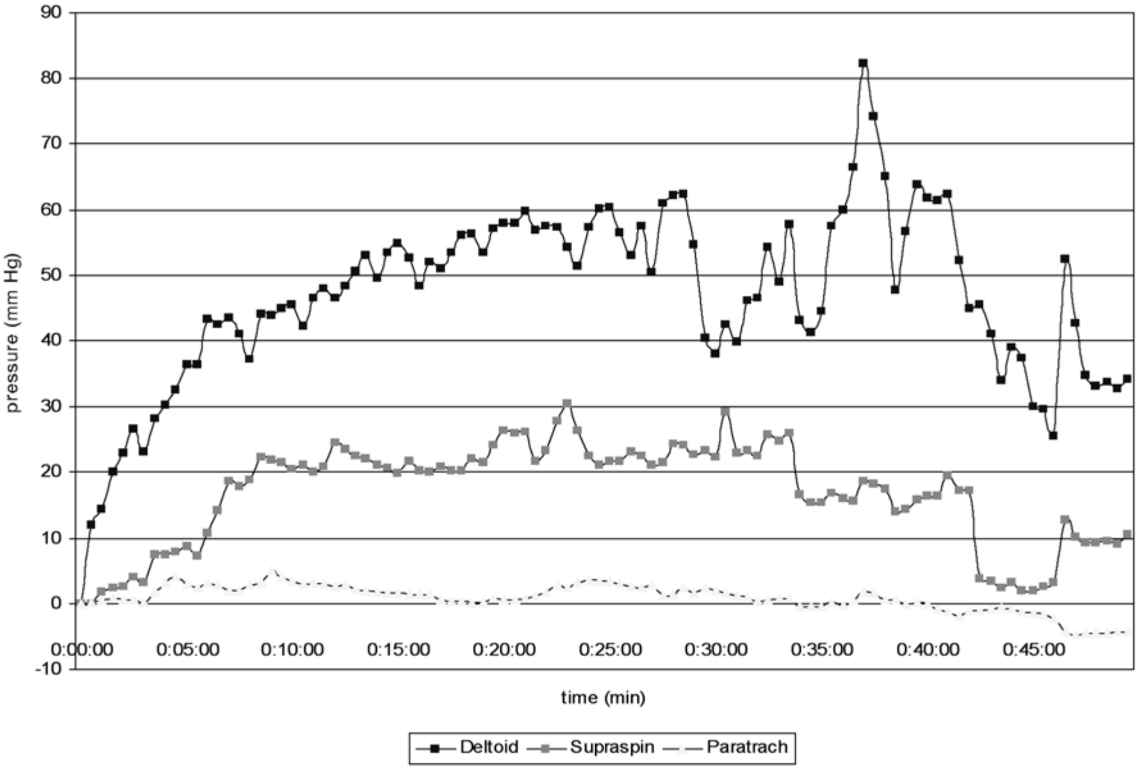
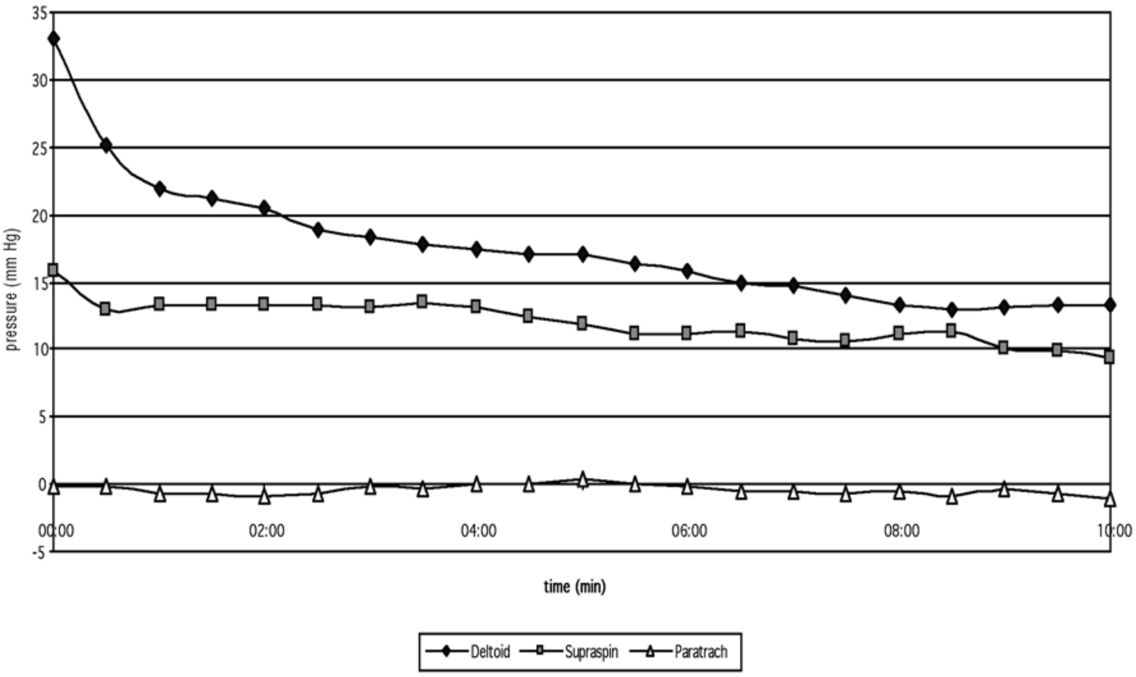


Table II. — Average pressure at ten minutes post-op for the 40 arthroscopic procedures in the three regions investigated



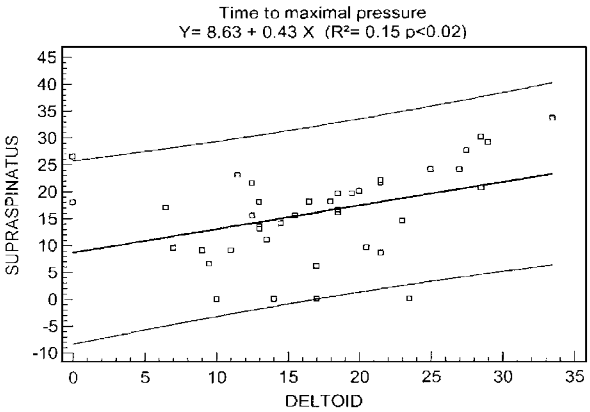


Fig. 3. — Prediction of the time needed to reach maximum supraspinatus pressure from measuring deltoid pressure.

Paratracheal pressure

Average peak pressure in the paratracheal region was 10.52 +/- 23.80 mmHg (range 0.00 to 133.36) during the procedure. There was no distinct trend in the evolution of the pressure. Pressure values were in a close range (+/- 5 mmHg) between baseline, minimum and maximum pressure levels during the entire procedure, for 35 patients. Paratracheal peak pressures for five patients reached (P1) 25.30 mmHg, (P2) 28.10 mmHg, (P3) 38.00 mmHg, (P4) 69.10 mmHg and (P5) 133.40 mmHg. In four of the five patients, peak pressures were reached during the initial 15 minutes of the surgery. In one patient (P2) peak pressure was reached near the end of the procedure. In this (P2) and one other patient (P3), paratracheal pressure did not drop to baseline within ten minutes after the procedure. Paratracheal pressures dropped to baseline levels, within ten minutes after the procedure, in the remaining 38 patients.

All patients were safely extubated without delay. None of the patients showed signs of respiratory distress in the immediate postoperative period.

Statistical analysis

Out of the explanatory variables (gender, BMI, and age) only age was a significant determinant for the time after which the maximum pressure was reached (only) in the supraspinatus muscle with the next equation :

Time to maximal pressure = 5.2 + 0.26 age + 1.31 gender – 0.12 BMI ($p < 0.05$).

The time to reach the maximum pressure in the supraspinatus muscle can be predicted with an error of 7.5 minutes from measurements in the deltoid muscle, and this relation was independent of gender and BMI. Time to reach maximal pressure in the supraspinatus is calculated by the equation :

$Y = 8.63 + 0.43 X$ ($R^2 = 0.15$, $p < 0.02$) (fig 3). No other correlations could be found between the pressures in the three regions.

DISCUSSION

Several potentially life-threatening events during arthroscopic shoulder surgery have been described in the literature. Lee *et al* (*7*) report on three patients who developed pneumomediastinum and bilateral pneumothorax. All patients were operated on in the sitting position under general anaesthesia with endotracheal intubation. A pressure pump was used for joint distension and a power shaver with suction was used for subacromial decompression. All patients recovered after appropriate treatment (chest tubes). The authors believe that the combination of a pressure pump and power shaver (Dyonics, EP-1, endoscopic powered instrument system, Smith & Nephew) with suction might have caused aspiration of air into the subacromial space and pushed the air subcutaneously into the pneumomediastinum.

We have found in the literature two case reports on complete airway obstruction during arthroscopic shoulder surgery (*3, 5*). Both patients were in lateral decubitus and had interscalene block anaesthesia. In both cases an infusion pump was used for joint distension. After approximately two hours of surgery, the patients developed clear signs of airway obstruction with difficulty breathing. One of the patients had to be intubated for 24 hours. They both recovered well.

Langlan *et al* (*6*) reported on a 25-year-old man who developed negative-pressure pulmonary oedema after shoulder arthroscopy. The patient was in the beach chair position, and an infusion pump was used. The authors believe that the patient's forceful inspiration against the endotracheal tube after finishing the arthroscopic procedure has caused this pathology. The arthroscopy itself was believed not to be part of the pathophysiology of this event.

Extravasation of fluid into the soft tissues during shoulder arthroscopy is often described as a harmless side effect, receding within four to ten minutes after the procedure (*8, 9*). Contrary to the literature, we found that levels of deltoid and supraspinatus pressure, at 10 minutes after surgery, did not completely recover to baseline levels. Furthermore, soft tissue distension was usually still visible, predominantly in the deltoid region, even after pressure had dropped to baseline levels. This makes us believe that – especially – the deltoid muscle has a certain buffer-capacity for retaining fluid, and releases this fluid accumulation only slowly over a larger amount of time than previously thought.

In almost half of our patients, deltoid muscle pressure and supraspinatus muscle pressures rose to a level well above levels that are thought to give rise to compartment syndrome (30 to 50 mmHg). None of the patients developed a clinical compartment syndrome, probably owing to the transient nature of the pressure rise. This is a common finding with previous studies.

Many orthopaedic surgeons prefer the use of an infusion pump over the use of pressurised saline bags during shoulder arthroscopy. Mean pressure of the pump is usually kept between 40 and 80 mmHg. The pressure on the saline bags we used was kept between 150 and 300 mmHg. Although we have no data to confirm this, we feel that we would have found similar results if we had used an infusion pump for fluid irrigation. Our average intramuscular peak pressures were similar to those reported in the literature. Using pressurised saline bags has never caused us problems of visualisation of the glenohumeral joint or the subacromial space. Several authors report on airway related complications during arthroscopic shoulder surgery, possibly caused (and/or aggravated) by their use of an infusion pump (*3, 5-7*). We consider these case reports as a warning for cautious use of an infusion pump during shoulder arthroscopy.

This is the first report on monitoring the soft tissue pressures in the paratracheal region during shoulder arthroscopy. In the literature, we found a few cases of life-threatening respiratory problems during shoulder arthroscopy. Two of them, due to tracheal compression, were most probably caused by fluid extravasation during the procedure. In our series, five out of 40 patients showed significant elevation of paratracheal pressures, rising in one case to an undoubtedly dangerous level of 133 mmHg. Fortunately, no respiratory problems occurred during or after these 5 procedures. This can probably be attributed to the fact that all patients had been intubated before the start of the procedure. Nevertheless all except two patients had baseline paratracheal pressure levels at the end of the procedure. There are no predictive measurements or variables for the paratracheal pressure. Careful monitoring of those patients in whom no endotracheal intubation but only a scalene block was used is mandatory. We feel that endotracheal intubation is a necessary measure when performing an arthroscopic subacromial decompression of the shoulder and most certainly in procedures of longer duration, such as arthroscopic stabilisations or cuff repairs. Moreover postoperative vigilance is mandatory even in intubated patients, since in two cases in the present study, the paratracheal pressure was not normalised within 10 minutes after the procedure.

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