Clinical Report

Laparoscopic extraperitoneal inguinal hernia repair complicated by subcutaneous emphysema

Claude E. Klopfenstein MD, Giovanni Gaggero MD, Chantal Mamie MD, Philippe Morel MD,* Alain Forster MD

The case of a healthy 59-yr-old man who underwent elective laparoscopic extraperitoneal inguinal hernia repair and general anaesthesia is presented. After one hour of surgery, a sudden increase in the $FETCO_2$ from 5.0% to 9.4% in relation to a massive subcutaneous emphysema, but without any haemodynamic instability, was noticed. The acute rise of $FETCO_2$ was the first sign of an abnormal event. Nevertheless, subcutaneous emphysema was diagnosed with chest wall examination and palpation. Subcutaneous emphysema and hypercarbia are potential complications of laparoscopic surgery, but are more likely to occur in extraperitoneal surgery, since insufflated CO_2 can diffuse easily into the surrounding tissues. High insufflation pressures will increase chances of this occurring and was the most likely cause of this complication. This case encouraged us to make recommendations for the management of laparoscopic extraperitoneal surgery which included: monitoring of CO_2 insufflation pressure, routine examination and palpation of chest wall, use of N_2O with caution, adjusting ventilation to physiological $FETCO_2$ and excluding other causes of subcutaneous emphysema and hypercarbia.

Il s'agit du cas d'un patient de 59 ans en bonne santé opéré sous anesthésie générale pour une hernie inguinale par laparoscopie et par l'abord extrapéritonéal. Soixante minutes après le début de l'opération, on note une augmentation subite et importante de la $FETCO_2$ qui passe de 5% à 9,4% sans manifestations hémodynamiques. Cette montée brutale de la $FETCO_2$ a été le premier signal de l'incident. L'emphysème sous-cutané n'a été diagnostiqué qu'après l'examen et la palpation des parois abdominale et thoracique. L'emphysème sous-cutané et l'hypercarbie représentent des complications potentielles de la chirurgie laparoscopique et sont plus susceptibles de survenir avec l'abord extrapéritonéal, parce que le CO_2 peut diffuser plus facilement dans les tissus environnants. Une pression d'insufflation trop élevée constitue le mécanisme le plus plausible de l'incident. Ce cas clinique nous offre l'opportunité de suggérer quelques recommandations pour la prise en charge de l'opéré par laparoscopie et abord extrapéritonéal: monitorage de la pression d'insufflation du CO_2, examen et palpation fréquents des paroi thoracique et abdominale, utilisation prudente du N_2O dans le mélange de gaz inspiré, règlage de la ventilation pour une $FETCO_2$ physiologique et exclusion de toutes les autres causes possibles d'emphysème sous-cutané et l'hypercarbie.

Key words
CARBON DIOXIDE: subcutaneous;
COMPLICATIONS: subcutaneous emphysema, hypercarbia;
EQUIPMENT: laparoscopy;
SURGERY: laparoscopic hernia repair.

From the Departments of Anaesthesiology and Surgery,* University Hospital of Geneva, Geneva Switzerland.
Address correspondence to: Dr. Claude E. Klopfenstein, Department of Anaesthesiology, University Hospital, 24, rue Micheli-du-Crest, 1221 Geneva-Switzerland.
Accepted for publication 28th January, 1995.

Introduced more than 20 yr ago for gynaecological procedures, laparoscopic surgery has now been extended to upper and lower abdominal surgery, and more laparoscopic operations are performed. Laparoscopic cholecystectomy is a widely accepted procedure and other laparoscopic operations are gaining acceptance, such as exploration of the common bile duct, repair for inguinal hernia, appendicectomy, bowel resection and fundoplication.[1] This development has given anaesthetists opportunities to face new challenges, to manage the physiopathological changes during laparoscopy and specific complications, such as pneumothorax, subcutaneous emphysema, pneumomediastinum, or gas embolism.[2-6] Recently, an extraperitoneal, preperitoneal, laparoscopic approach of the inguinal hernia repair has been described.[7,8]

This report describes the management of acute and massive subcutaneous emphysema which occurred during laparoscopic extraperitoneal inguinal hernia repair and considers some practical issues related to anaesthesia for this surgical procedure.

Case report

A 59-yr-old man, ASA I, 80 kg, 182 cm, was admitted for elective inguinal hernia repair using the laparoscopic technique. On preoperative anaesthetic assessment, general anaesthesia was discussed and informed consent obtained.

The patient received preoperatively 7.5 mg midazolam *po* one hour before surgery. He was monitored according to our standards: ECG, non-invasive blood pressure (Hewlett-Packard HP 78352), pulse oximetry, $F_{ET}CO_2$ and anaesthetic gas concentration (Datex Capnomac), nerve stimulator on orbicularis occuli muscle, oesophageal stethoscope and a thermometer.

After preoxygenation, anaesthesia was induced with fentanyl 0.1 mg, followed by thiopentone 400 mg; orotracheal intubation was facilitated with vecuronium 8 mg and anaesthesia was maintained with N_2O/O_2 (F_IO_2 = 40%) and isoflurane (0.5 to 0.8 vol%). The lungs were ventilated using a Dräger Sulla 808 machine at a tidal volume of 800 ml, a minute respiratory rate of 10 with a fixed I:E ratio of 1:2, peak intratracheal pressure varied between 18 to 22 cm H_2O. For surgical reasons, a urinary catheter was inserted. The patient received 1000 ml Ringer's lactate prior to induction and 5 $ml \cdot kg^{-1} \cdot hr^{-1}$ during surgery. Soon after draping, he was placed in the Tredelenburg position.

The beginning of surgery was uneventful, except for a mild increase in $F_{ET}CO_2$ (from 4.8% to 5.5%), which was compensated by increasing the minute ventilation from 6.5 $L \cdot min^{-1}$ to 7.0 $L \cdot min^{-1}$. The CO_2 insufflation pressure was monitored on the insufflator (OP-Pneu Wisap), and remained between 14 and 18 mmHg. Sixty minutes after beginning surgery, the anaesthetist noted a sudden increase in $F_{ET}CO_2$ (from 5.0% to 9.4%). Blood gas analysis confirmed hypercarbia (pH 7.2, $PaCO_2$, 10.53 kPa, PaO_2 20.6 kPa bicarbonate 29.9 $meq \cdot L^{-1}$, base excess 0.9 $meq \cdot L^{-1}$, oxygen haemoglobin saturation 99%). Haemodynamical variables and peak inspiratory pressure remained unchanged.

The surgeon was asked to discontinue the insufflation. Tidal volume was increased to 950 ml, respiratory rate to 14 bpm (minute ventilation: 13.3 $L \cdot min^{-1}$), and F_IO_2 to 1.0. Rapid examination and auscultation of the upper thorax were normal; ventilator or circuit leaks, malposition of the endotracheal tube, airway obstruction, pneumothorax, malignant hyperthermia and CO_2 embolus were ruled out.

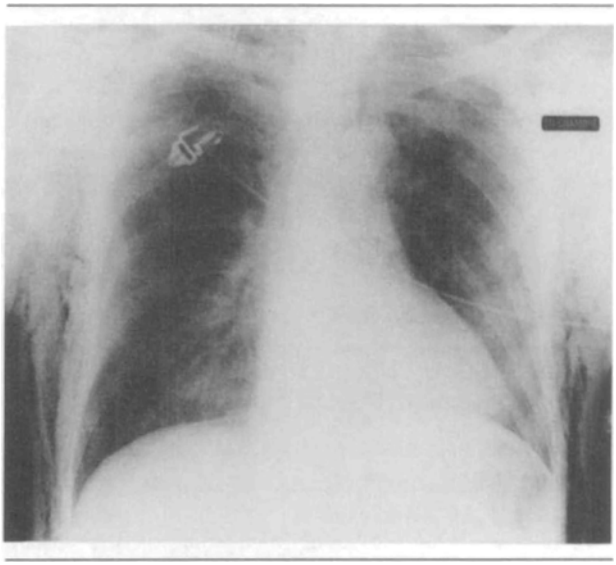

FIGURE Chest *x*-ray after extubation. Note subcutaneous emphysema round the chest wall.

On palpation of the lower part of the thorax under the drapes, crepitation consistent with subcutaneous emphysema was noticed, which spread quickly to the neck and the face. With hyperventilation (12–14 $L \cdot min^{-1}$), $F_{ET}CO_2$ decreased and remained at about 5.0%. The operation continued with hyperventilation and close monitoring of the CO_2-insufflation pressure (<12 mmHg). By that time, the face and neck emphysema had resolved and at the end of surgery, after reversing neuromuscular blockade, the patient began to breathe spontaneously and, 15 min later, the trachea was extubated with $F_{ET}CO_2$ and pulse oximetry values in the physiological range. The patient was discharged to the recovery room, alert, breathing adequately. Arterial blood gas analysis revealed normal values during spontaneous oxygen breathing by face mask (4 $L \cdot min^{-1}$). The chest *x*-ray confirmed the subcutaneous emphysema and excluded a pneumothorax (Figure). Twelve hours later, the patient was discharged from the recovery room to the ward. The subcutaneous emphysema lasted for 24 hr in the abdominal wall and the scrotum. The patient was discharged from hospital after 72 hr.

Discussion

Extensive subcutaneous emphysema has been reported after laparoscopic cholecystectomy and fundoplication, but not in association with laparoscopic extraperitoneal hernia repair.[3,4,9] In our case, the acute increase of $F_{ET}CO_2$ was the first sign that an abnormal event was occurring, but the emphysema was only diagnosed with chest examination and palpation, after having ruled out other possible causes of sudden increase in $F_{ET}CO_2$.

Laparoscopic surgery is a new challenge for anaesthetists, and anaesthesia complications, such as hypotension, oxygen desaturation, hypercarbia necessitating adjustment of ventilator setting, postoperative nausea and vomiting, have been well described.[2–6] Acute increase of $FETCO_2$ with hypercarbia and acidosis during a laparoscopic cholecystectomy has been related to massive CO_2 absorption from subcutaneous emphysema, due to malposition of the insufflation needle or to high CO_2 insufflation pressure.[4,5] In the case of laparoscopic fundoplication, subcutaneous emphysema regularly develops, because the opening of the peritoneum overlying the diaphragm allows CO_2 diffusion through the mediastinum to the cervico-cephalic region.[9]

Several techniques for laparoscopic inguinal hernia repair have been described, most of them using a patch repair. Whereas the intraabdominal laparoscopic hernia repair is performed with the use of three intraabdominal laparoscopic ports and a large sheet of prosthetic mesh, which is placed over the entire myopectinal orifice and secured with sutures or staples, after incision of the peritoneum overlying the inguinal floor,[1] the extraperitoneal approach is a recent development in laparoscopic surgery, confining CO_2 insufflation and placement of laparoscopic ports into the extraperitoneal space. After careful dissection of the extraperitoneal space around the hernia, respecting the integrity of the peritoneum, a large prosthetic mesh is implanted and spread out.[7,8] Although technically more challenging, this method potentially avoids the risks of intraabdominal organ lesion associated with laparoscopy and the occurrence of peritoneal adhesions. The advantages of this technique, low morbidity and low rate of recurrence, have been confirmed in a series of 300 patients, but anaesthetic complications were not mentioned.[7]

In our case, the high CO_2 insufflation pressure (between 15 to 18 mmHg), especially since the injection site was the preperitoneal space, probably explains the cause of the subcutaneous emphysema. Since this space is in continuity with the subcutaneous space, it explains the rapid diffusion of CO_2 and the subcutaneous emphysema, which by itself increases the gas exchange surface and consequently the hypercarbia. This was confirmed in a recent publication, where the CO_2 diffusion was more marked during extraperitoneal than during intraperitoneal CO_2-insufflation.[10]

The management of subcutaneous emphysema during laparoscopic procedure included hyperventilation, discontinuation of N_2O,[3,5] since nitrous oxide rapidly enters the gas space containing CO_2, adding to the supplementary gas volume.[11] This case encouraged us to make anaesthetic recommendations for the management of patients undergoing laparoscopic extraperitoneal hernia repair. These included: (1) monitoring of CO_2-inflation pressure (<12 mmHg); (2) routine and frequent examination and palpation of abdominal and chest wall to detect subcutaneous gas accumulation; (3) use of N_2O with caution; (4) adjusting the ventilation to an acceptable $FETCO_2$; (5) ruling out all other causes of subcutaneous emphysema and acute hypercarbia.

In summary, subcutaneous emphysema and hypercarbia are potential complications of laparoscopic surgery, but are more likely to occur in the preperitoneal laparoscopic inguinal hernia repair than during other laparoscopic procedures, since the insufflated CO_2 can diffuse more easily in the surrounding tissues. High CO_2 insufflation pressures are, thus, more dangerous than in intraperitoneal laparoscopy.

References

1 *Soper NJ, Brunt LM, Kerbl K.* Laparoscopic general surgery. N Engl J Med 1994; 330: 409–19.

2 *Rose DK, Cohen MM, Soutter DI.* Laparoscopic cholecystectomy: the anaesthetist's point of view. Can J Anaesth 1992; 39: 809–15.

3 *Pearce DJ.* Respiratory acidosis and subcutaneous emphysema during laparoscopic cholecystectomy. Can J Anaesth 1994; 41: 314–6.

4 *Kent RB III.* Subcutaneous emphysema and hypercarbia following laparoscopic cholecystectomy. Arch Surg 1991; 126: 1154–6.

5 *Kalhan SB, Reaney JA, Collins RL.* Pneumomediastinum and subcutaneous emphysema during laparoscopy. Cleve Clin J Med 1990; 57: 639–42.

6 *Wadhwa RK, McKenzie R, Wadhwa SR, Katz DL, Byers JF.* Gas embolism during laparoscopy. Anesthesiology 1978; 48: 74–6.

7 *Begin GF.* Cure coelioscopique des hernies de l'aine par voie prépéritonéale. Le Journal de Coelio-Chirurgie 1993; 7: 23–8.

8 *McKernan JB, Laws HL.* Laparoscopic repair of inguinal hernia using a totally extraperitoneal prosthetic approach. Surg Endosc 1993; 7: 26–8.

9 *Chiche JD, Joris J, Lamy M.* Respiratory changes induced by subcutaneous emphysema during laparoscopic fundoplication. Br J Anaesth 1994; 72: A37.

10 *Mullet CE, Viale JP, Annat GJ, et al.* Pulmonary CO_2 elimination during surgical procedures using intra- or extraperitoneal CO_2 insufflation. Anesth Analg 1993; 76: 622–6.

11 *Steffey E, Johnson BH, Eger EI II.* Nitrous oxide intensifies the pulmonary arterial pressure response to venous injection of carbon dioxide in the dog. Anesthesiology 1980; 52: 52–5.