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Gasless laparoscopic cholecystectomy: comparison of postoperative recovery with conventional technique

A.-M. KOIVUSALO, I. KELLOKUMPU AND L. LINDGREN

Summary

We have compared, in a randomized study in 26 patients, immediate and late postoperative recovery after elective laparoscopic cholecystectomy using the gasless, mechanical abdominal wall lift method with conventional carbon dioxide pneumoperitoneum. After the gasless method, tracheal extubation was performed significantly earlier than after the conventional method ($P < 0.01$). End-tidal carbon dioxide concentrations were significantly higher after pneumoperitoneum for 30 min after operation ($P < 0.01$). In the conventional group, deviation in Maddox–Wing recordings from preoperative values remained at a significantly higher level during the 3-h recovery room period ($P < 0.01$). There was a positive correlation between the total amount of carbon dioxide used and duration of drowsiness ($r = 0.61$, $P < 0.001$) and the Maddox–Wing deviation ($r = 0.62$, $P < 0.001$). Postoperative nausea and vomiting, and right shoulder pain occurred less often after the gasless method ($P < 0.05$). Late recovery criteria (ability to drink, void and walk) in patients in the gasless group were fulfilled approximately 7 h earlier than in those in the pneumoperitoneum group ($P < 0.01$). Gasless laparoscopic cholecystectomy resulted in more uneventful and faster immediate and late postoperative recovery than conventional carbon dioxide pneumoperitoneum. (*Br. J. Anaesth*. 1996; **77**: 576–580)

Key words
Surgery, laparoscopy. Complications, pneumoperitoneum. Recovery, postoperative.

Laparoscopic cholecystectomy has rapidly replaced open cholecystectomy as a standard treatment of symptomatic gallstones. Laparoscopic cholecystectomy restores pulmonary function better and enables less painful recovery, shorter hospitalization and faster return to normal activities than open cholecystectomy.[1] Induction and maintenance of carbon dioxide pneumoperitoneum can, however, have serious adverse physiological effects.[2–11] In addition to peroperative problems, postoperative sequelae are also seen not infrequently.[5] Insufflated carbon dioxide is absorbed into the circulation resulting in hypercapnia.[12] Furthermore, lung ventilation is the only mechanism for elimination of carbon dioxide. After conventional laparoscopic cholecystectomy, postoperative nausea and vomiting (PONV) have been reported in up to 68% of patients.[13 14] After laparoscopic cholecystectomy with combined low-pressure pneumoperitoneum and abdominal wall lift, the incidence of PONV was 8%.[5] In addition, postoperative drowsiness was also of significantly longer duration and right shoulder pain occurred more often after conventional carbon dioxide pneumoperitoneum.[5] Also, the more carbon dioxide used the more restless were patients in the recovery room.

Therefore, we evaluated to what extent a totally gasless method for laparoscopic cholecystectomy would affect the quality of immediate and late postoperative recovery.

Patients and methods

We studied 26 ASA I–II patients undergoing elective laparoscopic cholecystectomy. The study was approved by the local Ethics Committee and informed consent was obtained. Patients were allocated randomly to one of two groups. Patients in one group underwent laparoscopic cholecystectomy with conventional pressure pneumoperitoneum (CPP group) (intra-abdominal pressure (IAP) 12–15 mm Hg) with room temperature carbon dioxide insufflation. In the other group, a retractor (Laparolift TM, Origin Medsystems Inc., USA) (fig. 1) was used to elevate the abdominal wall upwards by 10–15 cm.[15] No carbon dioxide was used (retractor group). All operations were performed by the same experienced senior surgeon (I. K.).

Patients were premedicated with oral diazepam 0.2 mg kg^{-1} approximately 60 min before arrival in the operating theatre. Glycopyrronium 3 $\mu g\ kg^{-1}$ was given i.v. to all patients. Fluid administration of Ringer's acetated solution and hydroxyethyl starch (Plasmafusin, Pharmacia AB, Sweden) was standardized. Anaesthesia was induced with alfentanil 20 $\mu g\ kg^{-1}$ and propofol 1.6–2.5 mg kg^{-1}. Alfentanil 20 $\mu g\ kg^{-1}$ was given before the start of surgery in all patients. Neuromuscular block was provided with

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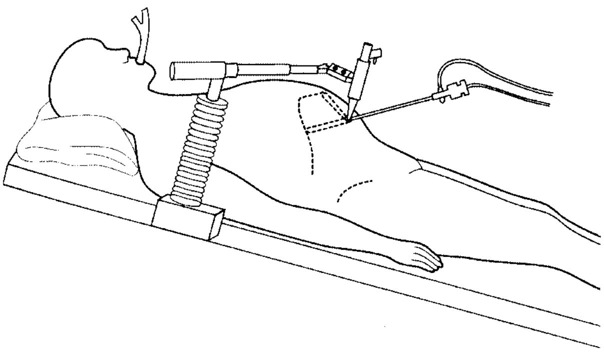

Figure 1 Schematic illustration of the retractor method.

atracurium and was monitored using the train-of-four technique. If the surgeon complained of stiffness of the abdominal muscles an additional bolus of atracurium 10 mg was given. Anaesthesia was maintained with desflurane at an end-tidal concentration of 6.1% (1 MAC) and oxygen in air (FI_{O_2} 0.4). No nitrous oxide was used. The lungs of all patients were ventilated mechanically at 10 bpm (Servo 900 C, Siemens Anmedic, Elema Schönander, Sweden). If needed, minute volume of ventilation was increased to maintain end-tidal carbon dioxide concentration at 4.5–5.0% (AS/3, Datex Ltd, Finland). Analgesia was achieved with an infusion of alfentanil 10–200 $\mu g\ kg^{-1}\ h^{-1}$ titrated to avoid increases in arterial pressures of more than 20% from the pre-anaesthetic value. The total amount of alfentanil used during anaesthesia was noted and neuromuscular block was not antagonized with neostigmine. After operation, patients were allowed to breathe spontaneously and the trachea was extubated when breathing was regular, end-tidal carbon dioxide was decreasing and laryngeal reflexes had recovered. In all patients, end-tidal desflurane was 1% or less at the time of extubation. The time interval from extubation until patients responded to commands and gave their date of birth was recorded.

After operation patients were followed up for 3 h in the recovery room. Abdominal pain at rest and during coughing, and right shoulder pain were assessed using a verbal rating scale (0–3). If the pain score was 2 or more the patient received oxycodone 0.07 mg kg^{-1} i.v. If the pain score remained 2 or more for more than 15 min the dose of oxycodone was repeated and ketorolac 30 mg i.v. was given. End-tidal carbon dioxide concentration was recorded after 1 deep breath hourly using a nose catheter (Cardiocap, Datex Ltd, Finland). Sedation was scored: 0 = fully awake, 1 = sedated, responding to commands, 2 = hardly responding to commands, 3 = not responding to commands. Restlessness was scored: 0 = calm, 1 = little movements all the time, 2 = needs someone to sit beside, 3 = needs sides for the bed. Drowsiness was scored: 0 = brisk, 1 = little tired, 2 = likes to sleep, 3 = does nothing but sleeps. A score of 2 or more was considered as sedation, restlessness or drowsiness. Duration of drowsiness and PONV were observed. Only vomiting was treated with droperidol 0.625 mg i.v. The baseline Maddox–Wing ocular test was performed on the day before operation after careful explanation of the use of the instrument to the patient.[16] Postoperative tests were performed hourly during the 3-h recovery room stay. Changes in the Maddox–Wing recording from the preoperative value were noted. All postoperative recordings were performed by a trained nurse unaware of the method used during operation.

Late recovery was recorded as the interval from tracheal extubation to the moment the patient was voluntarily able to void, drink and walk.

Patients were interviewed on the first day after operation, with special reference to pain and its location and PONV. All drugs needed during the first 27 h after operation were noted.

STATISTICAL ANALYSIS

Data within a group were analysed using one-way analysis of variance (ANOVA) with PLSD correction (least significant test). The differences between the two groups were analysed using two-way ANOVA with PLSD correction or Fisher's exact test for small groups.[17] Calculations were performed using Stat View 512 + TM software (Brain Power Inc., Calabasas, CA, USA). Correlations between the total amount of carbon dioxide and deviation in Maddox–Wing recordings from preoperative value and between duration of drowsiness were calculated. Data are expressed as mean (SD). $P < 0.05$ was considered statistically significant.

Results

The two groups were comparable in age, height, weight, ASA status and sex. Duration of operation was 108 (28) min in the retractor group and 85 (25) min in the CPP group ($P < 0.05$). Total amount of carbon dioxide was 55 (34) litre in the CPP group whereas in the retractor group carbon dioxide was not used ($P < 0.001$). Total amounts of alfentanil and propofol used were comparable in the two groups: in the retractor group 84 (70) $\mu g\ kg^{-1}$ and 2.3 (0.6) mg kg^{-1}, respectively, and in the CPP group, 104 (76) $\mu g\ kg^{-1}$ and 2.1 (0.4) mg kg^{-1}, respectively (ns). Atracurium was needed significantly more in the retractor group (1.0 (0.1) mg kg^{-1}) than in the CPP group (0.8 (0.2) mg kg^{-1}) ($P < 0.05$) (table 1).

Patients in the retractor group fulfilled the extubation criteria 10 (4) min after discontinuation of desflurane. This value was 23 (15) min in the CPP

Table 1 Patient characteristics, surgical and anaesthesia data (mean (SD or range) or number). CPP = Conventional pressure pneumoperitoneum. *$P < 0.05$, ***$P < 0.001$ between groups

	Retractor group (n=13)	CPP group (n=13)
Age (yr)	41 (27–59)	47 (27–73)
Height (cm)	167 (8)	167 (6)
Weight (kg)	70 (13)	72 (15)
ASA I/II	9/4	9/4
Sex (F/M)	12/1	12/1
Duration of op. (min)	108 (28)*	85 (25)
Total amount of CO_2 (litre)	0***	55 (34)
Atracurium (mg kg^{-1})	1.0 (0.1)*	0.8 (0.2)
Alfentanil (μg kg^{-1})	84 (70)	104 (76)

Table 2 Postoperative characteristics (mean (SD)). $^{*}P < 0.05$, $^{**}P < 0.01$ between groups

	Retractor group ($n = 13$)	CPP group ($n = 13$)
Extubation after discontinuation of anaesthetic (min)	11 (4)**	23 (15)
Skills after extubation		
Co-operation (min)	0.4 (0.4)	3 (4)
Orientation (min)	1 (1)	5 (11)
Able to (h)		
Drink	9 (5)	12 (7)
Void	10 (4)	14 (5)
Walk	11 (5)**	18 (4)
Duration of drowsiness (min)	31 (61)	82 (76)
Number of patients with		
Right shoulder pain	1*	7
Vomiting	1*	8
Doses of oxycodone per patient		
During the first 3 h	2.5 (1.3)	2.1 (1.7)
During the next 24 h	1.7 (1.1)	1.2 (1.2)

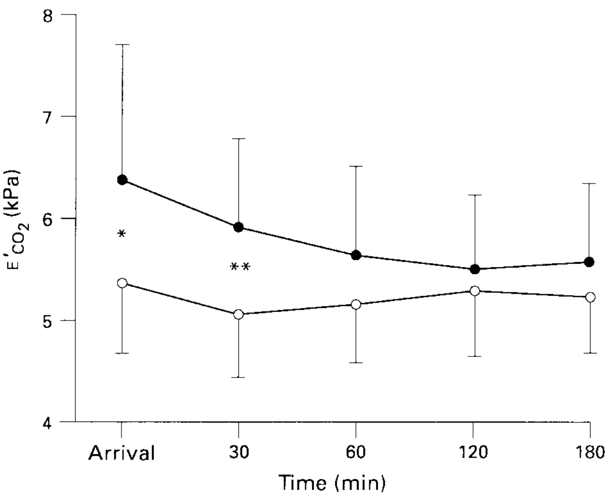

Figure 2 End-tidal carbon dioxide concentration (E'_{CO_2}) during the 3-h recovery room period in the retractor (○) and CPP (●) groups. $^{*}P < 0.05$, $^{**}P < 0.01$.

group ($P < 0.01$). Patients in the retractor group responded to commands 0.4 (0.4) min and gave their date of birth 1 (1) min after extubation. These values were 3 (4) min and 5 (11) min, respectively in CPP group (ns) (table 2).

End-tidal carbon dioxide values in the retractor group were significantly lower compared with those in the CPP group during the first 30 min after operation (fig. 2).

The Maddox–Wing test was recorded in 19 of 26 patients as the remainder were unable to see without spectacles. The deviation in Maddox–Wing recording from the preoperative value was significantly lower in the retractor group than in the CPP group, 2 h after operation ($P < 0.01$) (fig. 3). There was a positive correlation between the total amount of carbon dioxide used and deviation in Maddox–Wing values during the 3-h recovery room period (table 3).

Two patients in the CPP group were so restless that they needed sides for their beds. Amount of carbon dioxide used during operation in these patients was 103 and 40 litre. These two patients and one patient who needed 47 litre of carbon dioxide during operation were sedated (score >2)

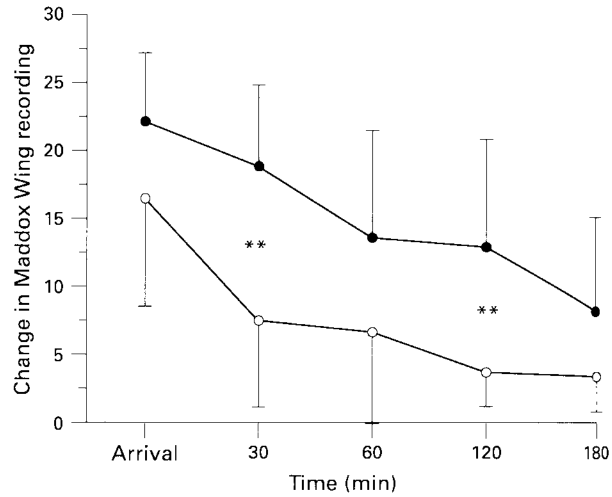

Figure 3 Deviation in Maddox–Wing recording from the preoperative value during the recovery room period in the retractor (○) and CPP (●) groups. $^{**}P < 0.01$.

Table 3 Correlation between the total amount of carbon dioxide used during laparoscopic cholecystectomy and the deviation of the Maddox–Wing test from the preoperative values for 3 h after operation

Time after arrival at recovery room	Correlation coefficient	*P*
Immediately	0.39	ns
30 min	0.55	< 0.01
60 min	0.5	< 0.01
120 min	0.5	< 0.01
180 min	0.62	< 0.001

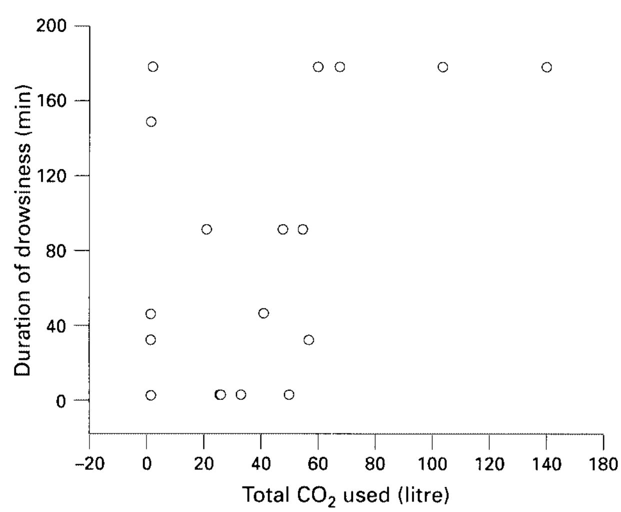

Figure 4 Correlation between duration of drowsiness and total amount of carbon dioxide used during laparoscopic cholecystectomy. $r = 0.61$, $P < 0.01$.

for the 3-h recovery room period. None of the patients in the retractor group was restless or sedated.

Postoperative drowsiness lasted 31 (61) min in the retractor group and 82 (76) min in the CPP group (ns). There was a correlation between duration of drowsiness and total amount of carbon dioxide used ($r = 0.61$, $P < 0.001$) (fig. 4). In those three patients who were drowsy during the recovery room period, the total amount of carbon dioxide used during laparoscopy was more than 60 litre.

Pain scores and location of the pain during the 3-h recovery room period were similar in both groups. There was no difference in the need for analgesics between groups.

In the recovery room, two patients in the retractor group and five patients in the CPP group needed droperidol for vomiting. During the next 24 h, the groups did not differ in the need for oxycodone (table 2) or ketorolac.

On the first day after operation one patient in the retractor group and seven patients in the CPP group suffered from right shoulder pain ($P < 0.05$). On the first day after operation, eight of 13 patients (62%) in the retractor group described pain in the abdomen "like tenderness after a hard muscle work-out". Pain was unpleasant but not unbearable.

During the next 24 h, one patient in the retractor group and eight patients in the CPP group suffered from vomiting ($P < 0.05$).

Patients in the retractor group were able to drink 9 (5) h after tracheal extubation. In the CPP group this value was 12 (7) h (ns). The interval from extubation to ability to void were 10 (4) h and 14 (5) h, respectively (ns). Patients were able to walk 11 (5) h after extubation in the retractor group and 18 (4) h in the CPP group ($P < 0.01$). In total, seven patients in the retractor group and one in the CPP group fulfilled the late recovery criteria[18] on the evening of the day of operation ($P < 0.05$) (table 2).

There were no perioperative surgical complications.

Discussion

In this study we have shown that postoperative recovery after laparoscopic cholecystectomy was faster and more uneventful when exogenous carbon dioxide was not used. In patients with the gasless method, the trachea was extubated earlier than in those with pneumoperitoneum. They were more often free from PONV and were able to walk earlier than patients after carbon dioxide insufflation.

Atracurium was needed more in the retractor group. This was probably because of the additional need for total relaxation of the abdominal muscles when the abdominal wall was lifted upwards with a force of 10–15 kg. Distension of the abdominal muscles might be painful and explain the similar need for peroperative alfentanil in the two groups. With the conventional method, the need for alfentanil can be explained by the release of endogenous catecholamines.[11]

In our study the duration of drowsiness correlated with the total amount of carbon dioxide used. Exogenous carbon dioxide is absorbed into circulation from the peritoneal cavity during operation and is exhaled via the lungs; this increased end-tidal carbon dioxide concentration occurred in our conventional pressure pneumoperitoneum group up to 1 h after operation. Retention of carbon dioxide might be one reason for prolonged drowsiness. When carbon dioxide is exhaled through the lungs, increased ventilatory drive is needed. In our patients, peroperative infusion of alfentanil was needed for attenuation of the circulatory response to carbon dioxide insufflation, and ventilation was probably inhibited by the residual effects of alfentanil infusion.[19]

The degree of divergence of the small eye muscles measured with the Maddox–Wing device has been found to correlate closely with clinical recovery of patients from general anaesthesia.[16] The Maddox–Wing tests in our patients returned earlier to the baseline level after the retractor method. Because there was a positive correlation between total carbon dioxide used during operation and changes in the Maddox–Wing test, it is probable that the slower recovery of divergence of eye muscles was attributed to the insufflated carbon dioxide. Thus exogenous carbon dioxide may significantly affect progress in early recovery.

PONV occurred significantly more often in patients with carbon dioxide insufflation. Carbon dioxide is a potent vasodilator of cerebral vessels. Increased intracranial blood flow has been seen during laparoscopic procedures.[20,21] Increased intracranial pressure is known to cause nausea and vomiting[22] which may be one reason for PONV in our and in earlier studies.[13,14] Higher end-tidal carbon dioxide concentrations during the 3-h recovery room period in our pneumoperitoneum group may also reflect higher concentrations of carbon dioxide in cerebral blood contributing to the occurrence of PONV. Also, alfentanil causes nausea and vomiting.[23]

Seven patients in the pneumoperitoneum group and only one in the retractor group suffered from right shoulder pain, which is referred pain caused by distension of the right phrenic nerve. Pain in some patients may be severe enough to warrant opioids.[24] In our study, however, the retractor method did not totally abolish right shoulder pain, probably because of diaphragmatic stretching produced by the retractor.

Our patients with the gasless method fulfilled the criteria for late recovery 7 h earlier than those with carbon dioxide pneumoperitoneum. These criteria are commonly accepted for discharge home.[18] More than 50% of patients with the gasless method could be discharged home on the evening of the operation whereas only one patient with carbon dioxide insufflation fulfilled these criteria. Eight patients (62%) in the pneumoperitoneum group needed droperidol for vomiting and required an overnight stay in hospital.

In principle, patients after laparoscopic cholecystectomy can be discharged from hospital on the evening of surgery.[25] However, the use of insufflated carbon dioxide may make this impossible. We suggest that the mechanical abdominal lift method without carbon dioxide insufflation for laparoscopic cholecystectomy may be the method of choice when considering laparoscopic cholecystectomy on a day-case basis.

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