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GENERAL GYNECOLOGY

Association between intraabdominal pressure during gynaecologic laparoscopy and postoperative pain

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Abstract
Purpose Laparoscopy is nowadays a well-established surgical method and plays a main role in an ever-increasing range of indications in gynaecology. High-quality studies of surgical techniques are necessary to improve the quality of patient care. The present study aims at evaluating postoperative pain after gynaecological laparoscopy depending on the intraoperative CO_2 pressure.
Methods In a prospective, monocentric, randomized single-blind study at the Department of Gynaecology and Obstetrics at the Hannover Medical School, we include patients scheduled for different laparoscopic procedures. Randomization of the intraoperative CO_2 pressure was carried out in six groups. Pain was assessed the day after surgery by the blinded nurse using a visual analogue scale.
Results 550 patients were included in the period from May 2013 to January 2016. The analysis of the per protocol population PPP ($n=360$) showed no statistically significant difference between the six intervention groups with regard to mean postoperative pain perception. In direct comparison between two groups, an intraoperative CO_2 pressure of 15 mmHg was associated with a significant higher pain score than a pressure of 12 mmHg. The difference was 7.46 mm on a 10 cm VAS.
Conclusions The results of our study indicate that a CO_2 pressure of 12 versus 15 mmHg can be advantageous. However, the clinical relevance remains unclear due to the low difference in pain. The additional benefit of an even lower pressure of 10 or 8 mmHg cannot be reliably assessed; we found signs of poor visibility conditions in these low pressure groups.

Keywords Laparoscopy · CO_2 · Pressure · Pain · Gynaecology

Introduction

Laparoscopic surgery is regarded as the gold standard for gynaecological treatment of many benign and malignant diseases over the past three decades. Indications for laparoscopic gynaecological surgery are diagnostic pelviscopies, tubal surgery, ovarian surgery, surgical interventions in the uterus (myomectomy, hysterectomy), urogynaecological surgery like sacrocolpopexy, endometriosis surgery and oncological surgery like radical hysterectomies and pelvic/paraaortal lymphonodectomies [1–3]. Compared to open abdominal procedures, minimal invasive surgery shows a lot of advantages like less perioperative morbidity, faster recovery and shorter hospitalisation without loss of effectiveness [4, 5]. Main risk factors for perioperative complications are highly complex surgical procedures, prior abdominal surgery and adipositas [6]. Frequent complications are injuries of the colon and small intestine, of arterial and venous vessels as well as of ureter and bladder [7]. Recently, lots of trials have been done to reduce surgical trauma and postoperative pain, which is one of the most common complaints during postoperative rehabilitation [8]. Several interdisciplinary studies assume that simple methods like reducing intraoperative pneumoperitoneal pressure are associated with better clinical outcome after laparoscopic cholecystectomy [9, 10].

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An artificially created pneumoperitoneum in laparoscopic procedures is the basis for the direct view of the internal organs. Pneumoperitoneum is defined as an air or gas accumulation in the peritoneal cavity and is nowadays usually created with carbon dioxide (CO_2) and called capnopneumoperituneum [3, 11].

Advantages of CO_2 are as follows: It is not flammable, it has a high solubility in blood, and therefore, less risk of a gas embolism, less abdominal and shoulder pain compared with room air, a better view because of a better anti-fog characteristic compared with room air, less toxicity than room air, and better possibility to reduce high blood concentrations through mechanical hyperventilation [11–13]. However, a capnopneumoperitoneum has haemodynamic effects as well as consequences on ventilation and respiration [14]. The pneumoperitoneal pressure plays a role for a lot of factors during the operation [14].

The following reasons for pain are known after laparoscopic surgery due to the effect of CO_2 pneumoperitoneum: Peritoneal stretching, diaphragmatic irritation, diaphragmatic injury, and shoulder abduction during surgery [15, 16]. Postoperative pain components in laparoscopic surgery include incisional pain (parietal pain), deep intra-abdominal pain (visceral pain), and shoulder pain (approximately referred visceral pain) [8].

There are possibilities known to reduce pain initiated by laparoscopy like using smaller trocars [17] or using body tempered and moistened CO_2 gas [18] as well as administration of local anaesthetic intraabdominal and near the incision of the trocars [19–22]. All these factors are discussed controversially so the European Association for Endoscopic Surgery does not generally recommend these interventions in their guidelines [23].

The effect of a lower pneumoperitoneal pressure during minimal invasive laparoscopic surgery on postoperative pain still remains unclear [24–27], especially in gynaecologic pelvic surgery.

The aim of this prospective study was to analyse the effect of a differing intraoperative pneumoperitoneal pressure on visceral pain, parietal pain and referred visceral pain after gynaecological laparoscopic pelvic surgery.

Materials and methods

This prospective study was performed at the department of Gynecology and Obstetrics, Hannover Medical School, Germany. The study was approved by the Ethics Committee of Hanover Medical School. Written informed consent was obtained from all individual participants included in the study. Participants were recruited from all patients presenting in our clinic in which a laparoscopic surgery was indicated. Including criteria were female patients older than 16 years with the necessity of gynaecological laparoscopy during the period from May 2013 to January 2016. The following gynaecological laparoscopic surgical interventions were included: Ovarian cystectomy, diagnostic laparoscopy, salpingectomy, adnexectomy, hysterectomy, extirpation of endometriosis, adhesiolysis. We did not include patients with laparoscopic sterilization as we do this procedure only very rarely due to large outpatient clinics in our city. Excluding criteria were an intraoperative conversion to laparotomy, serious postoperative complications, which had an influence on sensation of pain. A higher grade of physical status according to the American Society of Anaesthesiologists (ASA 3 or 4) was no excluding criteria.

550 patients were randomized into six different intraabdominal insufflation pressure groups (group 1: initial pressure 15 mmHg, intraoperative pressure 10 mmHg, group 2: initial pressure 10 mmHg, intraoperative pressure 10 mmHg, group 3: initial pressure 15 mmHg, intraoperative pressure 12 mmHg, group 4: initial pressure 12 mmHg, intraoperative pressure 12 mmHg, group 5: initial pressure 15 mmHg, intraoperative pressure 8 mmHg, group 6: initial pressure 15 mmHg, intraoperative pressure 15 mmHg). Initial pressure was changed into the intraoperative pressure after insertion of all trocars, approximately 3 min after beginning of the surgery.

We always used the same general anaesthesia protocol. After induction of general anaesthesia, pneumoperitoneum was induced using a Veress needle at the umbilicus with CO_2 at using room temperature with 0% relative humidity with a rate of 6 l/min with an intraabdominal pressure according to the randomized protocol. This pressure was held constantly by automatic regulation of the CO_2 inflow. The Trendelenburg position was always adjusted at 30 degrees. We routinely used four working ports, one 10-mm umbilical for the camera and three 5-mm trocars in the lower abdomen. A gastric tube was placed routinely by the anaesthetist. Foley catheter was routinely used for bladder drainage. A Robinson wound drainage was inserted in required cases. At the end of the operation, residual intraabdominal CO_2 was evacuated by compressing the abdomen.

The following study parameters were recorded: patient age, gravidity and parity, body mass index (BMI, calculated as weight in kilograms divided by the square of height in meters), previous surgery, type and duration of surgery, quantity of bleeding during surgery, length of hospital stay and total amount of CO_2 used during surgery. Evaluation of pain was performed three times a day (between 6 and 7 a.m., 12 a.m.–1 p.m. and 7–8 p.m.). The patients were invited to mark their pain intensity on a visual analogue scale (VAS), ranging from 0 to 10 cm (0 means no pain; 10 cm describes the most severe pain). The patients were also asked for the leading pain to evaluate any diffuse, dull aching pain in the abdomen representing visceral pain or shoulder representing referred visceral pain. Both patients and resident physicians were single-blinded to the randomization. All patients were given, if required, standard postoperative non-opioid-analgesia (paracetamol, ibuprofen, diclofenac, metamizol) as well as opioid analgesia according to the level scheme by WHO. Routine analgesia was given after measurement of VAS pain score (between 6 and 7 a.m., 12 a.m.–1 p. m. and 7–8 p.m.). The total amount of required analgesic infusions during the postoperative period was documented for each patient.

Primary outcome measures were the following:

- The effect of different intraoperative pneumoperitoneal pressure on visceral pain, parietal pain and referred visceral pain after gynaecological laparoscopic pelvic surgery.
- The effect of different intraoperative pneumoperitoneal pressure on the outcome of gynaecological laparoscopic pelvic surgery.

For statistical analysis we used IBM SPSS Statistics (IBM® SPSS® Statistics, Version 21.0. for Microsoft Windows, ©IBM Corporation Released 2012, Armonk, NY, USA). To calculate the necessary number of patients, we performed a power calculation. We performed a descriptive statistic to evaluate the patient characteristics. A single-factor variance analysis (ANOVA) was performed for continuous parameters to detect a significant difference between the six intervention groups. For categorical variables a cross-table was created and the Chi square test according to Pearson was used. If >20% of the cells in the cross-over table had an expected frequency of less than five, the exact significance of the Fisher's exact test was read instead of the asymptotic significance of the Chi square test. A single-factor variance analysis was performed for the detection of an influence of intraoperative CO_2 pressure on the postoperative pain sensation. The pain on the first postoperative day in the morning was defined as a dependent variable. The belonging to an intervention group was defined as an independent variable. For the subgroup analysis, the *t* test was used for independent samples. For the detection of further factors of influence on the postoperative pain sensation, the age, type of therapeutic intervention, duration of operation and the number of prior abdominal operations were defined as fixed factors and a univariate analysis was performed. In a following two-factorial variance analysis (ANCOVA) the significant influencing factors were defined with the subgroups as fixed factors and their influence and interaction on postoperative pain was tested. To control the first type of error, post-hoc multiple comparisons (Tukey test) were carried out. The results of the intervention groups were graphically represented as mean ± standard deviation (range) and with the help of tables and diagrams. Graphs regarding the evaluation of the target parameter show the mean + 95% confidence interval. The significance level was set to $p < 0.05$ for all statistical tests.

Results

We included 550 patients during a period from 01.05.2013 to 31.01.2016. 450 patients formed the intention-to-treat-population (ITTP). The reasons for dropout were conversion to laparotomy ($n = 27$), no laparoscopy ($n = 24$), no surgery ($n = 24$), double inclusion into our study ($n = 10$) and postoperative complications with influence on the pain ($n = 9$).

For our analysis we evaluated the per-protocol-population (PPP) with 360 patients. The following reasons led to the exclusion of the 90 patients: intraoperative deviation from the randomized CO_2-pressure ($n = 45$), missing documentation of the uses of CO_2-pressure ($n = 26$) and non-compliance of the surgeon ($n = 19$).

The middle age of our PPP was 43 years (16–87 years) and the mean BMI was 25.4 (16.7–45.9). 25% of the population were smokers. On average, each patient had 1.11 (0–11) surgical interventions before our surgery. Table 1 shows all evaluated general patient characteristics.

Table 2 shows the surgical characteristics of our included population. The average duration of operation was 73.6 min with 105 hysterectomies, 155 ovarian surgeries, 36 myomectomies, 42 laparoscopies with duration under 60 min and 22 unclassified surgeries. The average hospital stay was 2.9 (0–8) days. 346 out of 360 were inpatients and 14 outpatients. 251 of the inpatients (72.5%) demanded non-opioid-analgesics the first day after surgery and 2 out of 14 outpatients (14.3%) demanded non opioid analgesics before release.

We found some statistical significance in this part of the evaluation. Patients in the intervention group 5 had the shortest average duration of hospital stay (2.4 days) and the lowest need for analgesics the first day after surgery (1.1 doses). Compared to this, patients in the intervention group 6 had the longest duration of hospital stay (3.3 days) and the highest need for analgesics (1.8 doses). Table 3 shows the postoperative course in the different intervention groups.

To evaluate the postoperative pain after laparoscopy in the PPP ($n = 360$), we analysed the patient`s pain in the morning of the first postoperative day ($n = 326$, 90.6%); in 14 cases we had to use the last documented pain at the day of surgery (3.9%) and in 20 cases we averaged the neighboured pain values of the surgery day and the day after surgery (5.6%) due to missing entries for the patient`s pain in the morning of the first postoperative day.

Table 1 General patient's characteristics in the intervention group

Intervention group	1 (15 to >10 mmHg)	2 (10 to >10 mmHg)	3 (15 to >12 mmHg)	4 (12 to >12 mmHg)	5 (15 to >8 mmHg)	6 (15 to >15 mmHg)	*p*
General characteristics	*n* = 68	*n* = 34	*n* = 67	*n* = 56	*n* = 62	*n* = 73	
Age at the time of surgery in years	42.8 ± 12.0 (22–76)	41.6 ± 12.6 (20–77)	45.5 ± 13.3 (16–85)	45.1 ± 11.9 (18–75)	41.6 ± 14.3 (16–80)	43.1 ± 13.6 (19–87)	0.469[a]
Amount of deliveries	1.1 ± 1.2 (0–5)	1.0 ± 1.1 (0–4)	1.3 ± 1.2 (0–6)	1.0 ± 1.0 (0–3)	1.1 ± 1.4 (0–7)	0.9 ± 1.0 (0–3)	0.514[a]
BMI	25.3 ± 5.1 (17.3–43.8)	24.4 ± 4.3 (18.4–39.3)	24.7 ± 5.5 (17.6–39.7)	26.0 ± 5.3 (16.7–41.6)	25.2 ± 5.8 (17.4–42.0)	26.2 ± 6.2 (19.0–45.9)	0.452[a]
Other diagnosis							
Adipositas	13 (19.1%)	2 (5.9%)	8 (11.9%)	11 (19.6%)	13 (21.0%)	15 (20.5%)	0.311[b]
Alcohol abuse	1 (1.5%)	1 (2.9%)	0 (0.0%)	1 (1.8%)	0 (0.0%)	1 (1.4%)	0.656[c]
Art. hypertension	8 (11.8%)	3 (8.8%)	11 (16.4%)	8 (14.3%)	11 (17.7%)	15 (20.5%)	0.603[b]
Chronic bowel disease	1 (1.5%)	0 (0.0%)	1 (1.5%)	2 (3.6%)	0 (0.0%)	1 (1.4%)	0.728[c]
Chronic pain syndrome	1 (1.5%)	0 (0.0%)	0 (0.0%)	1 (1.8%)	0 (0.0%)	1 (1.4%)	0.841[c]
Diabetes mellitus	4 (5.9%)	0 (0.0%)	1 (1.5%)	3 (5.4%)	3 (4.8%)	5 (6.8%)	0.496[c]
Nicotin abuse	17 (25.0%)	10 (29.4%)	20 (29.9%)	8 (14.3%)	18 (29.0%)	22 (30.1%)	0.346[b]
Psychiatric disease	6 (8.8%)	3 (8.8%)	3 (4.5%)	8 (14.3%)	7 (11.3%)	11 (15.1%)	0.371[b]
Rheumatic disease	2 (2.9%)	1 (2.9%)	2 (3.0%)	0 (0.0%)	1 (1.6%)	4 (5.5%)	0.591[c]
Preoperative long-term medication							
Analgetics	2 (2.9%)	0 (0.0%)	0 (0.0%)	3 (5.4%)	2 (3.2%)	8 (11.0%)	0.023[c]
Antidepressants	2 (2.9%)	4 (11.8%)	1 (1.5%)	7 (12.5%)	6 (9.7%)	10 (13.7%)	0.044[b]
Psychotropic drugs	1 (1.5%)	0 (0.0%)	1 (1.5%)	4 (7.1%)	1 (1.6%)	3 (4.1%)	0.383[c]
Benzodiazepines	0 (0.0%)	0 (0.0%)	1 (1.5%)	0 (0.0%)	0 (0.0%)	2 (2.7%)	0.620[c]
Prior surgery							
Amount of abdominal surgery	1.2 ± 1.3 (0–5)	1.3 ± 1.9 (0–10)	1.1 ± 1.2 (0–4)	1.2 ± 1.1 (0–5)	0.9 ± 1.1 (0–5)	1.0 ± 1.6 (0–11)	0.722[a]
Amount of laparoscopies	0.6 ± 1.1 (0–5)	0.7 ± 1.9 (0–10)	0.4 ± 0.8 (0–3)	0.5 ± 0.8 (0–3)	0.5 ± 0.7 (0–3)	0.6 ± 1.2 (0–8)	0.756[a]
Amount of laparotomies	0.6 ± 0.9 (0–3)	0.6 ± 0.8 (0–3)	0.7 ± 0.9 (0–3)	0.7 ± 0.9 (0–3)	0.5 ± 0.8 (0–3)	0.5 ± 0.8 (0–3)	0.397[a]
Amount of lateral laparotomy	0.6 ± 0.9 (0–3)	0.6 ± 0.7 (0–3)	0.7 ± 0.9 (0–3)	0.6 ± 0.8 (0–3)	0.5 ± 0.8 (0–3)	0.4 ± 0.7 (0–3)	0.419[a]
Amount longitudinal laparotomy	0.0 ± 0.1 (0–1)	0.0 ± 0.2 (0–1)	0.0 ± 0.0 (0)	0.1 ± 0.3 (0–1)	0.0 ± 0.0 (0)	0.0 ± 0.2 (0–1)	0.090[a]

[a]single-factor variance analysis

[b]Chi-square test according to Pearson

[c]Exact test according to Fisher

Table 2 Characteristics of surgical procedures in the intervention group

Intervention group	1 (15 to >10 mmHg)	2 (10 to >10 mmHg)	3 (15 to >12 mmHg)	4 (12 to >12 mmHg)	5 (15 to >8 mmHg)	6 (15 to >15 mmHg)	*p*
Total amount of surgery	*n* = 68	*n* = 34	*n* = 67	*n* = 56	*n* = 62	*n* = 73	
Duration of surgery (min)	73.3 ± 36.4 (23–204)	65.2 ± 28.9 (24–148)	84.9 ± 49.7 (17–242)	76.4 ± 39.5 (19–205)	58.5 ± 31.7 (17–177)	78.3 ± 38.0 (16–156)	0.003[a]
Kind of surgery							0.024[b]
1. Hysterectomy	26 (38.2%)	5 (14.7%)	22 (32.8%)	21 (37.5%)	6 (9.7%)	25 (34.2%)	
2. Ovarian surgery	22 (32.4%)	21 (61.8%)	27 (40.3%)	21 (37.5%)	34 (54.8%)	30 (41.1%)	
3. Laparoscopy duration <60 min	13 (19.1%)	4 (11.8%)	5 (7.5%)	6 (10.7%)	9 (14.5%)	5 (6.8%)	
4. Enucleation of myoma	5 (7.4%)	2 (5.9%)	8 (11.9%)	6 (10.7%)	9 (14.5%)	6 (8.2%)	
5. Other surgery	2 (2.9%)	2 (5.9%)	5 (7.5%)	2 (3.6%)	4 (6.5%)	7 (9.6%)	

[a]Single-factor variance analysis

[b]Chi-square test according to Pearson

Table 3 Postoperative course in the intervention group

Intervention group	1 (15 to >10 mmHg)	2 (10 to >10 mmHg)	3 (15 to >12 mmHg)	4 (12 to >12 mmHg)	5 (15 to >8 mmHg)	6 (15 to >15 mmHg)	*p*
Total amount of surgery	*n* = 68	*n* = 34	*n* = 67	*n* = 56	*n* = 62	*n* = 73	
Duration of hospital stay	2.9 ± 1.3 (0–5)	2.9 ± 1.3 (0–6)	2.9 ± 1.3 (0–6)	3.3 ± 1.5 (0–8)	2.4 ± 1.3 (0–6)	3.3 ± 1.5 (1–8)	0.003[a]
Postoperative pain medication							
Outpatient	*n* = 4	*n* = 1	*n* = 2	*n* = 3	*n* = 4	*n* = 0	
Medication at the day of surgery							
Non-opioid-analgesics	0.0 ± 0.0 (0)	2.0 (2)	0.5 ± 0.7 (0–1)	0.0 ± 0.0 (0)	0.0 ± 0.0 (0)	–	0.000[a]
Opioid-analgesics	0.0 ± 0.0 (0)	0.0 (0)	0.0 ± 0.0 (0)	0.0 ± 0.0 (0)	0.0 ± 0.0 (0)	–	–
Inpatient	*n* = 64	*n* = 33	*n* = 65	*n* = 53	*n* = 58	*n* = 73	
Medication at the first day after surgery							
Non-opioid-analgesics	1.5 ± 1.3 (0–6.7)	1.4 ± 1.2 (0–4)	1.3 ± 1.3 (0–5)	1.3 ± 1.2 (0–5)	1.1 ± 1.1 (0–4.2)	1.8 ± 1.2 (0–4)	0.023[a]
Opioid-analgesics	0.0 ± 0.0 (0)	0.0 ± 0.0 (0)	1.6 ± 13.2 (0-106.6)	1.6 ± 11.0 (0–80)	0.3 ± 2.6 (0–20)	1.4 ± 8.6 (0–70.5)	0.765[a]

[a]Single-factor variance analysis

The mean value of pain intensity was 2.96 ± 1.99 on a 10-cm VAS as seen on Fig. 1. 213 patients in the PPP specified the localisation of maximal pain (67.6%). 96% indicated a maximal abdominal pain, 9% a maximal shoulder pain and 2% in other localisations (multiple selection was possible). Table 4 shows the postoperative pain referred to the intervention groups. The mean pain values reached from the lowest value in the intervention group 4 (2.52) to the highest value in intervention group 6 (3.26). This difference was statistical significant ($p = 0.036$).

Regarding the general patient`s characteristics, characteristics of surgery and postoperative course, both groups are comparable. We also examined other factors which could significantly influence the postoperative pain. Here, we could demonstrate that the patient`s age has a significant effect on postoperative pain. A higher age is significantly

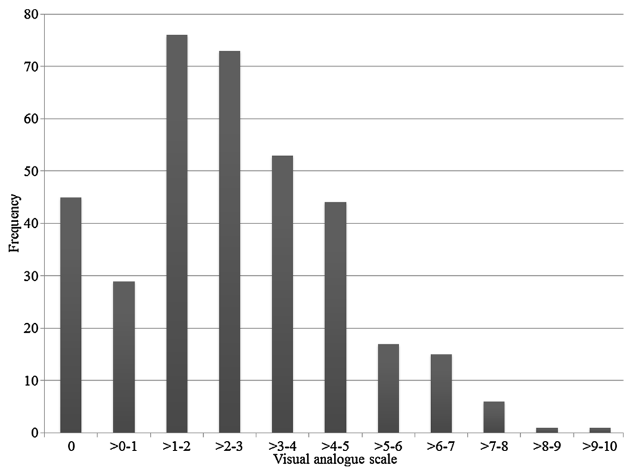

Fig. 1 Frequency distribution of pain intensity in the per-protocol-population (PPP, $n=360$)

associated with less pain as shown in Fig. 2. We found a maximum of difference of pain intensity (29.9 mm) between the group of patient's age under 20 years and the group of patient's age over 80 years.

There is also a significant relation between pain and the extent and duration of the surgery. Our results show that patients complain about more pain after hysterectomy than after surgery with a duration under 60 min ($p=0.019$). The results of our study demonstrate that a hysterectomy leads to an average higher pain score of 11.1 mm compared to an operation with a duration under 60 min at day one after surgery (Fig. 3).

We found a statistical relevance between postoperative pain and the amount of prior operations. Patients with two prior laparotomies had significantly more pain than patients with one prior laparotomy ($p=0.016$) as well as patients without prior operation ($p=0.006$). We could show an average higher pain level of 11.6 mm in the group of patients with two prior laparotomies compared to patients without prior operations.

Discussion

Laparoscopy has become an important method in surgical gynaecology. Also highly complex oncological procedures can be performed by laparoscopy. For purposes of quality assurance surgical standards and guidelines have to be defined [2]. For this high-quality studies are required, which investigate surgical-technical standards and outcome-related parameters by laparoscopy. The topics discussed in the literature include the amount of intraoperative CO_2 pressure and the influence on postoperative pain. The postoperative pain is considered to be very important for optimal patient care. Previously published gynaecological studies on the impact of intraoperative CO_2 pressure led to inconsistent results [28, 29]. There is a tendency that an intraoperative CO_2 pressure of 15 mmHg leads to more pain than a pressure of 12 mmHg or less [4, 9, 28–30]. The aim of the present study was to evaluate the intensity of postoperative pain after gynaecological laparoscopy, depending on the intraoperative CO_2 pressure.

Therefore, we designed a prospective, single-centre, randomized, single-blinded study. This randomized study leads to a maximal reduction of systematic bias.

The results of our study show that the average pain level is higher with an intraoperative CO_2 pressure of 15 mmHg compared with a pressure of 12 mmHg, but a reduction of

Table 4 Postoperative pain in the intervention group

Intervention group	1 (15 to >10 mmHg)	2 (10 to >10 mmHg)	3 (15 to >12 mmHg)	4 (12 to >12 mmHg)	5 (15 to >8 mmHg)	6 (15 to >15 mmHg)	p
Amount of surgery	$n=68$	$n=34$	$n=67$	$n=56$	$n=62$	$n=73$	
Target parameter on the VAS (cm)	3.00 ± 2.03 (0–10)	2.93 ± 1.92 (0–8)	2.95 ± 1.98 (0–7)	2.52 ± 2.09 (0–8)	2.96 ± 1.97 (0–8)	3.26 ± 1.90 (0–8.5)	0.479[a]
Localisation of pain, if VAS >0	$n=60$	$n=31$	$n=59$	$n=43$	$n=54$	$n=68$	
No information	$n=18$	$n=7$	$n=21$	$n=20$	$n=16$	$n=20$	
Information	$n=42$	$n=24$	$n=38$	$n=23$	$n=38$	$n=48$	
Stomach	42 (100%)	24 (100%)	35 (92.1%)	23 (100%)	37 (97.4%)	43 (89.6%)	0.085[b]
Shoulder	2 (4.8%)	3 (12.5%)	4 (10.5%)	1 (4.3%)	5 (13.2%)	5 (10.4%)	0.740[b]
Others	0 (0.0%)	0 (0.0%)	1 (2.6%)	1 (4.3%)	0 (0.0%)	2 (4.2%)	0.498[b]

[a] Single-factor variance analysis

[b] Exact test according to Fisher

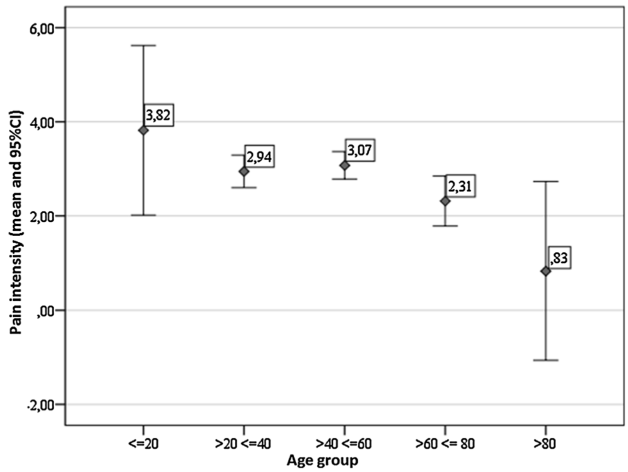

Fig. 2 Frequency distribution of pain intensity referred to the patient's age

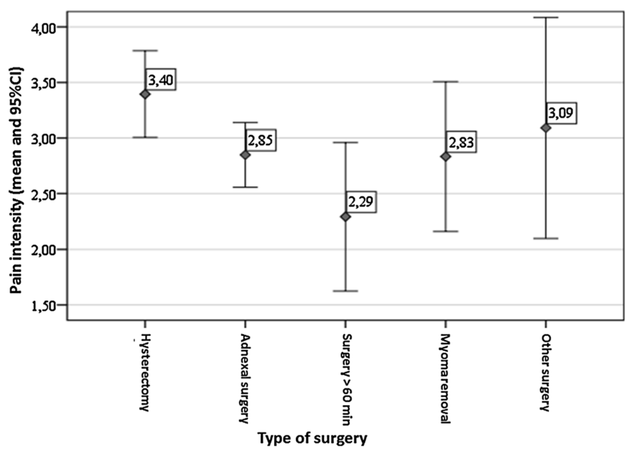

Fig. 3 Frequency distribution of pain intensity referred to the kind of surgery

the CO_2 pressure to 10 or 8 mmHg does not lead to safe pros or cons.

The potentially different effects of the initial CO_2 pressure compared to the intraoperative pressure on postoperative pain intensity have not been discussed in the literature yet.

We found the lowest mean pain in the intervention group 4 (2.52) and the highest value in intervention group 6 (3.26). This difference (7.46 mm on a 10 cm VAS) is statistically significant ($p = 0.036$).

Referring to the general patient`s characteristics, characteristics of surgery and postoperative progress, both groups are comparable.

The significantly higher painkiller consumption of the stationary patients in the intervention group 6 is noticeable. The higher average pain level in this group of patients represents a plausible explanation for the greater need for analgesics. We also found the longest duration of hospital stay in this group.

The clinical relevance of the above mentioned results is inconclusive. The literature uses the term "minimum clinically important difference" or MCID. Prior studies evaluated the necessity of MCID to be between 9.4 and 13 mm on a 10-cm VAS to effect a change in pain perception [31–34], while we found a MCID of 7.46 mm on a 10-cm VAS. On the other hand, our results were statistically significant for the parameters pain perception, amount of painkiller consumption as well as duration of hospital stay. Therefore, our suggestion would be to prefer an intraoperative CO_2 pressure of 12 mmHg compared with 15 mmHg. Topcu et al. came to a similar conclusion in 2014 with a patient collective of 150 patients undergoing only laparoscopic ovarian surgery. The result of this study was less pain in the group of patients with an intraoperative CO_2 pressure of 8 mmHg compared with 12 and 15 mmHg. The above mentioned MCID was 13.4 mm on a 10-cm VAS which underlines the clinical relevance of these results [10]. On the other hand, the authors found a significantly longer duration of surgery when using an intraoperative CO_2 pressure of 8 mmHg. Our study could not reproduce these findings. But we found a tendency of intraoperative increasing the CO_2 pressure in the intervention group with 8 and 10 mmHg, which could be interpreted as a sign of poor visibility conditions in the low pressure groups.

Bogani et al. as well as Kyle et al. also analysed the effect of laparoscopic CO_2 pressure on postoperative pain [9, 28–30, 35]. Bogani et al. found a difference of 11.9 mm (8 versus 15 mmHg) and 9 mm (12 versus 15 mmHg) on a 10-cm VAS and came to the conclusion that the use of lower CO_2 pressure leads to less pain perception [28]. In contrast Kyle et al. compared an intraoperative CO_2 pressure <12 mmHg with a pressure >12 mmHg and found only a difference of 5 mm on a 10 cm VAS so that they could not recommend a lower intraabdominal CO_2 pressure [29]. A possible explanation of these different conclusions could be that Kyle et al. combined 12 and 15 mmHg in one group so that they could not determine the difference of postoperative pain in these two important groups.

In addition to the amount of CO_2 pressure other important factors for postoperative pain perception play a role. General patient factors like demographic, social or psychological influences affect the sensation of pain in different ways [36–38]. Pre-existing conditions as well as nicotine consumption may affect the intensity of pain and the need for analgesics [39].

In this context the results of our study could demonstrate that the patient`s age has a significant effect on postoperative pain. A higher age is significantly associated with less pain. We also found a statistical relevance between postoperative pain and the amount of prior operations. Patients with two prior laparotomies had significantly more pain than patients with one prior laparotomy as well as patients without prior operations. There is also a significant relation between pain and the extent and duration of the surgery. Our results show that patients complain about significantly more pain after hysterectomy than after surgery with duration of less than 60 min.

Conclusion

In summary, the results confirm the positive, but probably poorly relevant, effect of a lower intraoperative CO_2 pressure on the postoperative pain the first day after surgery. In particular, the clinical outcome with the use of a pressure of 12 mmHg compared to 15 mmHg seems to be better. The additional benefit of an even lower pressure of 10 or 8 mmHg cannot be reliably assessed, while we found a tendency of intraoperative increasing the CO_2 pressure in the low pressure groups as a sign of poor visibility conditions.

Apart from the importance of the CO_2 pressure we also found other factors to play an important role in the postoperative sensation of pain like patients' age, amount of prior operations and duration of the surgery.

These factors as well as the use of low intraoperative CO_2 pressure need further investigations in order to clarify the importance in the clinical setting.

Author contribution SK: Protocol and project development, data collection, data analysis, manuscript writing. CW: Data collection, data analysis, manuscript editing. Hermann Hertel: Data collection, manuscript editing. PH: Project development, Data collection, manuscript editing. RK: Data collection, data analysis, manuscript editing. PS: Protocol and project development, data collection, data analysis, manuscript editing.

Compliance with ethical standards

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Conflict of interest We have no possible conflict of interest to mention. We certify that we have no affiliation with or financial involvement in any organization or entity with a direct financial interest in the subject matter or materials discussed in the manuscript (e.g., employment, consultancies, stock ownership, honoraria).
This article does not contain any studies with animals performed by any of the authors. No animals were involved in this study.

Ethical approval All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards. Informed consent was obtained from all individual participants included in the study prior to any study procedure.

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