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Review Article

Spinal Anesthesia for Laparoscopic Cholecystectomy

Abstract

In 1985, the first laparoscopic cholecystectomy was performed, and the introduction of laparoscopic cholecystectomy proved to be a new era in the management of cholelithiasis. In his only start, only patients who were good surgical risks, with non acute disease and no prior abdominal surgeries were selected for the procedure. However, as experience was gained, the pool of patients expanded to encompass those who were otherwise candidates for conventional cholecystectomy. To perform the surgery laparoscopically, there is a need to create a space between the abdominal wall and the viscera. If cholecystectomy was performed under anesthesia in high-risk patients, there is no explanation for the procedure to become routine in healthy patients.

Spinal anesthesia has the advantage of providing analgesia and muscle relaxation with complete preservation of consciousness and rapid postoperative recovery. No need to change the surgical technique, only that the inflation pressure should be maintained between 8 and 10 mmHg. One of the problems is the appearance of shoulder pain, which can be seamlessly decreased with low intra-abdominal pressures and systematic use of intraperitoneal local anesthetics. Spinal anesthesia reduces the incidence of nausea and vomiting and improves postoperative pain and allows early ambulation and discharge. The cost of spinal anesthesia was 30% of general anesthesia.

Introduction

In 1985, Prof Dr Erich Mühe of Germany performed the first laparoscopic cholecystectomy (LC) [1]. He performed 94 such procedures before another surgeon, Phillipe Mouret of Lyon, France, performed his first laparoscopic cholecystectomy in 1987 [2], who said: "*Laparoscopy is the only method capable of performing a complete and valid surgical exploration of the abdomen, with the peritoneal cavity in nearly physiological conditions, except for the elevation of the anterior abdominal wall.*" In 1988, the authors reported using this technique on 36 patients [2]. A gynecologist, William Saye, collaborated with general surgeon Barry McKernan to perform the first laparoscopic cholecystectomy in the United States [3].

Reddick and Olsen described their initial series of 25 patients in whom laser laparoscopic techniques were used to remove the gallbladder [4]. Several studies published in series, results supported decreased morbidity and reduction in hospitalization when compared to the traditional method for cholecystectomy. In 1990, my group performed the first laparoscopic under general anesthesia lasting more than four hours.

State-of-the-art 1990's imaging technology was harnessed to visualize a diseased organ. Special instruments were conceived to manipulate these organs. Laparoscopic sutures and loops were refined along with clip appliers, staples, tackers and gastrointestinal staplers. Perhaps the most important of these developments was the laparoscopic clip applier, for this humble instrument gave inexperienced general surgeons the confidence that ducts and blood vessels could be quickly secured. Once this confidence was established, all else followed. The introduction of laparoscopic cholecystectomy proved to be a new era in the management of cholelithiasis.

Selection and Preparation of Patients

When laparoscopic cholecystectomy was first performed, only patients who were good surgical risks, with non acute disease and no prior abdominal surgeries were selected for the procedure [2]. However, as experience was gained, the pool of patients expanded to encompass those who were otherwise candidates for conventional cholecystectomy, and some surgeons included patients who had acute disease [5]. Current absolute contraindications are peritonitis, which could be aggravated by the laparoscopic technique [6]. Laparoscopic surgery was successfully performed in patient's anticoagulated [7], during pregnancy [8] and morbidly obese [9]. Choledocholithiasis also has been considered a relative contraindication to the procedure because of the difficulty of laparoscopically removing stones in the common bile duct. However, newly developed instruments are useful for exploration of and stone retrieval from the common bile duct.

Laparoscopic Technique

Until recently the choice of anesthetic technique for upper abdominal laparoscopic surgery is mostly limited to general anesthesia with muscle paralysis, tracheal intubation and intermittent positive pressure ventilation (IPPV). At induction of anesthesia it is important to avoid stomach inflation during ventilation as this increases the risk of gastric injury during trocar insertion. Tracheal intubation and IPPV ensure airway protection and control of pulmonary ventilation to maintain normocarbia. Ventilation with a large tidal volume of 12-15 mL/kg prevents progressive alveolar atelectasis and hypoxemia and allows for more effective alveolar ventilation and carbon dioxide elimination [10].

To perform the surgery laparoscopically, there is a need to create a space between the abdominal wall and the viscera to allow adequate surgical team display and manipulation of abdominal contents. Although there are mechanical methods of abdominal distention, abdominal insufflation gas is a standard practice. The patient's abdominal cavity is insufflated to a pressure of 10 to 14 mm Hg with 2-4 L of CO_2 through a 1cm peri-umbilical incision. A laparoscope connected to a video monitor is then introduced through this incision to assist in accurate placement of three additional 5-mm to 10-mm subcostal cannulas evenly spaced from the midline to the right anterior axillary line. With the help of an assistant, subsequent manipulations are performed entirely through these four ports, with videoscopic guidance provided by the laparoscope. Blunt dissection is used to isolate the cystic duct and cystic artery. The cystic artery is double clipped and divided. Many surgeons then routinely perform cholangiography by clipping the cystic duct proximal to its junction with the common bile duct and inserting a small catheter into the cystic duct through a small distal incision. When the anatomy is clearly defined after cholangiography, the cystic duct is then double clipped and ligated, and the gallbladder is dissected free from the liver bed by using either electrocautery or a laser for cutting and hemostasis. Once the gallbladder is dissected free from the liver, the laparoscope is usually switched to another port, and the gallbladder is pulled through the umbilical site, neck first, with a forceps. The CO_2 is subsequently expelled through the ports by opening the cannulas, and the skin incisions are then closed with subcuticular absorbable sutures and sterile adhesive tape.

Monitoring

The electrocardiogram, noninvasive arterial pressure monitor, airway pressure monitor, pulse oximeter, end-tidal carbon dioxide concentration monitor, peripheral nerve stimulation and body temperature probe are routinely used. A urinary catheter is usually placed to minimize the risk of bladder injury and improve surgical exposure. The urine output should be monitored in patients with compromised cardiopulmonary function. The expired CO_2 is easily monitored with an adapter placed in the nose. Persistent refractory hypercapnia or acidosis may require deflation of the pneumoperitoneum.

Regional Anesthesia

Until the last century regional techniques had not been reported for laparoscopic or surgical procedures in the upper abdominal region. Epidural anaesthesia has been used for outpatient gynaecological laparoscopic procedures to reduce complications and shorten recovery time after anesthesia. Local or regional anesthetic techniques have not been reported for laparoscopic cholecystectomy or other upper abdominal surgical procedures except in patients with cystic fibrosis. A high epidural block (T_2-T_4 levels) is required to abolish the discomfort of surgical stimulation of the upper gastrointestinal structures. The high block produces myocardial depression and reduction in venous return, aggravating the hemodynamic effects of tension pneumoperitoneum.

Many researchers have observed that performing laparoscopic surgery under regional analgesia carries many advantages. The reduction of surgical stress response is considered one of its major advantages. This is accomplished through two aspects; the laparoscopic technique, itself which reduces the degree of tissue trauma and consequently the injury response (minimal invasive surgery concept), and the spinal analgesia itself which provides pain relief by blocking afferent neural block, together with block of various humoral mediator cascade systems [11]. Avoidance of airway instrumentation and lower incidence of deep vein thrombosis are other important advantages of this technique.

Surprisingly, in the era of minimally invasive medicine, regional anesthesia has not gained popularity in LC. Regional block such as low thoracic epidural [12], spinal [13], and combined spinal-epidural [14] blocks have been used in patients with relevant medical problems. This is due mainly to the notion that laparoscopic cholecystectomy requires tracheal intubation to prevent aspiration and respiratory complication due to the introduction of CO_2 in the peritoneum [15], which would not be well tolerated by an awake patient during the procedure [16].

Spinal anesthesia has the advantage of providing analgesia and muscle relaxation with complete preservation of consciousness and rapid postoperative recovery. In addition, there is a protection against the potential complications of general anesthesia.

Spinal Anesthesia Technique

In general, laparoscopic procedures of the abdominal cavity necessitate endotracheal intubation and mechanical ventilation due to the induction of pneumoperitoneum. The increased intra-abdominal pressure together with the increased carbon dioxide load to the lungs are considered as better managed under mechanical ventilation, making thus general anesthesia a necessary requirement for these operations. In the past decade, a small number of reports appeared involving regional anesthesia for laparoscopic general surgery, including patients with coexisting pulmonary disease who were deemed high risk for general anesthesia. More recently, a limited number of studies showed the feasibility of the application of regional anesthesia on healthy subjects.

Reports for laparoscopic general surgery under regional anesthesia alone included patients with coexisting pulmonary disease, who are deemed high risk for GA. Recently, some studies compared to general anesthesia with spinal anesthesia for laparoscopic [17,18], with some advantages for regional technique.

After monitoring and venipuncture patients were monitored with non-invasive blood pressure, oxygen saturation, and expired CO_2. An 18F catheter was inserted in the left hand for hydration and administration of drugs.Fentanyl (1μg/kg) and midazolam (1 mg) were administered before the subarachnoid puncture.

With the patient in left lateral decubitus or sitting position, after establishing aseptic conditions, the subarachnoid space was punctured between the L_3-L_4 apophyses with a 27G cut-bevel or pencil-point needle. Backflow of CSF confirmed the position of the needle in the subarachnoid space; after the administration of 20 μg of fentanyl, 3 mL of hyperbaric bupivacaine were injected. Afterwards, patients were placed in the supine position with a 10-20 degree head-down. The stylet of the needle was used to test the lack of sensitivity of the patient, which should reach the level of T_3. Once the goal was achieved, the surgical table was paced in the horizontal position and the patient was cleared for surgery.

Recently the anatomy of the thoracic spinal canal was investigated with magnetic resonance imaging in 50 patients [19]. It was also demonstrated the safety of spinal anesthesia with puncture at T_{10} using the combined spinal-epidural [20,21] or single puncture technique [22]. In one recent study of 300 patients, it was demonstrated that thoracic puncture using a cut point needle or pencil point needle was associated with the same incidence of paresthesia as was the lumbar approach, and without sequelae [23].

It is well known that anesthetists often fail to correctly identify the vertebral level. In 2000, the authors [24] investigated anesthetist's ability to identify a marked lumbar space; they showed that vertebral levels were identified correctly only 29% of the time. The T_{10} level was the landmark correctly identified by the largest number (92%) of anesthesiologists [24]. However, only 2% performed procedure thoracic spinal anesthesia [24].

Laparoscopic cholecystectomy has rapidly become a popular alternative to open cholecystectomy, and is considered a cost-effective technique for the treatment of symptomatic cholelithiasis. Spinal anesthesia has some advantages compared with general anesthesia [18,26], including the patient being awake and oriented at the end of the procedure, less postoperative pain, and the ability to ambulate earlier than patients receiving general anesthesia. The laparoscopic cholecystectomy may be performed at the level of thoracic puncture T_{10} [27]. The initial replacement and medications used are the same when performing lumbar puncture. In the case of thoracic puncture, it can be performed either in the lateral position or in a sitting position, depending on the preference of the anesthesiologist. The only modification needed is to decrease the dose of hyperbaric bupivacaine for half (7.5 mg) [27] of used (15 mg) in lumbar puncture [18,27]. Must remain the same cefalodeclive and wait for the level of anesthesia reaching the thoracic segment T_3.

In a study comparing full dose and lumbar puncture with half the dose and thoracic puncture the following significant differences were observed [27] (Tables 1, 2 and 3). There was no difference in operative time, length of pneumoperitoneum in the incidence of shoulder pain and nausea and vomiting. The most important result is the reduction of time of motor block, which allowed the passage of the operating table in 60% of patients versus none with full dose. Differences in the duration of motor and sensory block may be partly due to the smaller dose of bupivacaine and is consistent with previous reports [13]. Our study demonstrated a reduction in the duration of motor block in relation to sensory block of 45.9% with bupivacaine 15 mg and 33% with bupivacaine 7.5 mg [27]. This can be explained by deposition of the hyperbaric dose predominantly on the sensory nerve roots (posterior) in relation to the motor nerve roots (anterior and in this case uppermost) [28]. This explains the quality of the analgesia during the postoperative period. The 50% reduction in the dose of hyperbaric bupivacaine provided faster recovery from motor block, enabling 60% of patients to move from the table to the stretcher unaided, making this technique excellent for ambulatory surgery. The low-dose strategy may thus have an advantage in ambulatory patients because of the earlier recovery of motor and sensory function.

Table 1: Full dose and lumbar puncture compared to low dose and thoracic puncture [27].

Data	15 mg	7.5 mg
Time until T3 (minutes)	7:2±1:1	2:7±0:5
Hipotension (No/Yes)	43 / 27	60 / 10
Bradycardia	3 (4%)	7 (2.6%)
Move from the table to the stretcher unaided (No/Yes)	70 / 0	28 / 42
Sensitive block (hours)	4:14±(0:36)	2:35±0:25
Motor block (hours)	3:06±0:27	1:17±0:15

Table 2: Characteristics in all groups in perioperative period (mean (SD)) [18,27].

Parameters	15 mg (n=75)	7.5 mg (n=264)	P-value
Pneumoperitoneum (min)***	37.5 (11.6)	34.2 (8.31)	0.0561
Shoulder pain*	9 (12%)	22 (8.3%)	0.3822
Nauseas/Vomiting*	1 (1.3%)	0	0.6350
Rescue fentanyl*	8 (10.6%)	32 (12.1%)	0.2343
Table to stretcher*	0	164 (62%)	<0.0001

*Fischer's exact test
**Chi-square test
***Kruskal-Wallis test

Table 3: Spinal anesthesia related complication in postoperative period (mean (SD)) [18,27].

Parameters	15 mg (n=75)	7.5 mg (n=264)	P-value
Shoulder pain*	4 (5.3%)	7 (2.6%)	0.4223
Nauseas/Vomiting*	2 (2.6%)	0	1.0000
Prurido*	4 (5.3%)	6 (2.2%)	0.4340
Urinary retention*	0	0	1.0000
Headache*	1 (1.3%)	4 (1.5%)	1.0000
Recomended spinal*	74 (98.6%)	262 (99.2%)	0.4260

*Fischer's exact test

Spinal Fentanil

Spinal fentanyl is often combined with local anesthetic to prolong the sensory block spinal anesthesia [30]. In a double-blind, controlled trial to determine the optimal dose of intrathecal fentanyl in small dose hypobaric lidocaine spinal anesthesia for outpatient laparoscopy was studied [31].This study found that at least 25 µg of fentanyl needs to be added to 20 mg lidocaine to ensure reliable, durable hypobaric spinal anesthesia for laparoscopy, reduce shoulder-tip pain, and minimize the need for intraoperative supplementation. This dose provides longer postoperative analgesia and does not increase side effects apart from pruritus.

A high spinal anesthesia with the local anesthetic pure produces subclinical sedation, decreasing the need for propofol monitored by bispectral index (BIS) [32]. There was an increase in the number of patients sedated with increasing dose of fentanyl and sedation describes this as extremely advantageous intraoperatively in patients undergoing cesarean section, not receiving other sedative medications [33].

The direct effect of fentanyl in the brain is the result of rostral migration, causing sedation. Fentanyl injected into the lumbar region showed high-level spinal concentration four minutes after injection, and the largest increase occurred from 20 to 60 minutes [34]. In two studies with the dose of 25 µg of fentanyl consumption average was 3 mg midazolam [18,27] when the injection was lumbar and consumption of midazolam 2 mg was when the injection was thoracic [27]. Thus, the addition of intrathecal fentanyl should improve the quality of the block and provide postoperative analgesia.

Nasogastric Tube

Patients being operated on under general anesthesia, unlike spinal anesthesia, frequently have an additional problem of stomach inflation as a result of mask ventilation, and this often requires nasogastric or orogastric tube intubation, which amounts to unnecessary intervention of a body cavity. Unlike other authors [35], a nasogastric (NG) tube was not used routinely in our patients. We believe that the nasogastric tube is uncomfortable in awaken patients, and its need would be one of the criteria for conversion of the anesthesia. None of 34 patients in the spinal anesthesia group required a NG tube compared to 14 patients in the general anesthesia group [18]. This confirms that the anesthesiologist by inflating the stomach while ventilating with a face mask during induction and before intubation is the main responsible for the need of a nasogastric tube. Likewise, in 140 patients with spinal comparing high and low doses, there was no need to use NG for gastric emptying [27].

Pneumoperitoneum

Tension pneumoperitoneum causes an elevation in IAP which produces deleterious effects on cardiovascular, pulmonary, renal and metabolic functions. The creation of the pneumoperitoneum is the essential component for laparoscopic procedures. There are several characteristics which are considered optimal for this gas. As the surgical procedure may involve electrocautery, the gas which cannot support combustion is essential. Although oxygen and air would not have significant physiological consequences when absorbed, they support combustion and also would have significant deleterious effects with intravascular embolization. The following gases have been used: nitrous oxide, helium and argon. Because of the problems with other gases, CO_2 remains the only agent commonly used during laparoscopic procedures. The patient's position may have significant effects on the hemodynamic consequences of pneumoperitoneum. Increased intra abdominal pressure associated with pneumoperitoneum may compress venous capacitance vessels causing an initial increase, followed by a sustained decrease in pre-load. In healthy subjects undergoing laparoscopic cholecystectomy, using transoesophageal Doppler has shown that cardiac output is depressed to a maximum of 28% at an insufflation pressure of 15mm Hg but is maintained at a insufflation pressure of 7mmHg [36].

Controversy exists as to what defines an "adequate," "appropriate," or "sufficient" pneumoperitoneum prior to insertion of the primary trocar. Traditionally, it has been defined by an arbitrary volume of 1 L to 4 L of CO_2 or an arbitrary intraperitoneal pressure of 10 to 15 mm Hg [37]. The pressure technique has been adopted by many surgeons worldwide, but the appropriate volume to establish an appropriate intra-abdominal pressure remains controversial. Final pressures up to 7, 8, 10, 11, 14 and 15 mmHg have been advocated.

Pneumoperitoneum causes cephalad displacement of the diaphragm, resulting in the reduction in lung volumes including functional residual capacity. Pulmonary compliance is reduced and airway resistance is increased [38], producing a higher airway pressure (PAW) for any given tidal volume with an increased risk of haemodynamic changes and barotrauma during intermittent positive pressure ventilation (IPPV). Restriction in diaphragmatic mobility promotes uneven distribution of ventilation to the nondependent part of the lung, resulting in ventilation-perfusion mismatch with hypercarbia and hypoxemia. The ventilatory impairment is more severe if there is associated airway and alveolar collapse. Increase in IAP also predisposes to regurgitation of gastric contents and pulmonary aspiration [39]. The cephalad movement of the diaphragm may cause displacement of the endotracheal tube tip and endobronchial intubation [40].

Using intraperitoneal pressure of 8 mmHg, low-flow CO_2 administration, there was no need of increased intra-abdominal pressure in two recent study [18,27]. In an earlier study of 3,492 patients, the authors concluded that laparoscopic cholecystectomy done under spinal anesthesia does not require any change in technique and, at the same time, has a number of advantages when compared with general anesthesia, and should be the anesthesia of choice [41].

Low pressure pneumoperitoneum appears effective in decreasing pain after laparoscopic cholecystectomy.

Intraperitoneal Local Anesthetic

Laparoscopic cholecystectomy is the treatment of choice for symptomatic cholelithiasis. Administration of intraperitoneal local anesthetic, either during or after surgery, is used by many surgeons as a method of reducing postoperative pain. This technique was first evaluated in patients undergoing gynecological laparoscopic surgery [42]. Its application in laparoscopic cholecystectomy was initially examined in a randomized trial in 1993 [43]. Since then, many trials evaluating the efficacy of intraperitoneal local anesthetic in laparoscopic cholecystectomy have been published worldwide. Some authors have suggested that the timing of local anesthetic administration has an important role in the success of the technique. Several authors have used this technique for the treatment of shoulder pain immediately after the placement of the trocar [18,27,44] that occurs in high incidence during spinal anesthesia, and in some patients conversion to general anesthesia [45] was necessary. It has been argued that postoperative pain is reduced if suppression of central neural sensitization by intraperitoneal local anesthetic occurs before nociceptive stimuli have triggered the activation of pain pathways, compared with afterwards.

There is little evidence with regard to which type of local anesthetic is most effective because limited data are available for drugs other than bupivacaine. Some authors recommend the use of lidocaine for its immediate effect [18,27]. Bupivacaine itself (or levobupivacaine) is an excellent choice for intraperitoneal local anesthetic because of its long duration of action. Linear regression analysis of the VAS pain scores from all trials using bupivacaine or levobupivacaine suggested that there was a significant correlation ($P=0.02$; $R2=0.32$) between the strength of bupivacaine used and difference in pain score between treatment and control groups, i.e., larger concentrations of bupivacaine resulted in larger reductions in pain score [46]. However, there was no significant correlation between the volume or total quantity of local anesthetic. Overall, in a recent systematic review and meta-analyses does lend limited support to the use of intraperitoneal local anesthetic in laparoscopic cholecystectomy as part of a multimodal approach to pain management [46]. The technique seems to be safe and results in a statistically significant reduction in early postoperative abdominal pain. It may be of particular benefit when the operation is planned as an ambulatory procedure to improve same-day discharge rates. Alkhamesi and al. have successfully used the aerosolazation technique in the management of postoperative pain following laparoscopic cholecystectomy [47]. They showed that bupivacaine aerosol significantly reduced pain in comparison to control and to the administration of local anesthetic in to the gall bladder bed. The other study demonstrated that the aerosolization technique is safe in bariatric patients and can be used to deliver intraperitoneal therapeutics during laparoscopic procedures [48].

Hypotension and Bradycardia

Hypotension, with an incidence depending on the study, is one of the most frequent side effects of spinal anesthesia. Different incidences of hypotension, as reported in the literature, can be due to varying definitions and different methods of measurement. Hypotension following spinal anesthesia is mainly occurs due to sympathetic blockade leading to peripheral vasodilatation and venous pooling of blood. As a result, there is decreased venous return and cardiac output leading to hypotension.

Strategies for treating spinal anesthesia induced hypotension include i.e. volume administration, which increases circulating volume and cardiac output in an effort to compensate for the expansion of the capacitance vessels. Is part of the technique of spinal anesthesia for laparoscopic cholecystectomy infusion of 500 mL of Ringer's lactate before subarachnoid block.

Hypotension is due to sympathetic blockade and mechanical effect of pneumoperitoneum. Hypotension is a well-known problem of spinal anesthesia that was easily managed and did not affect the planned procedure [18,27]. An incidence of 59% [26], 43.3% [49] and 41% [18] with conventional lumbar spinal were reported previously. However, with the thoracic spinal low dose and the use of the incidence of hypotension was 10% [20], 14.2% [27] and 13.3% [49]. In two study segmental thoracic spinal anesthesia resulted in better hemodynamic stability with significantly lesser vasopressor support than lumbar spinal anesthesia [27,49].

This sympathetic block is rarely complete and some preservation of sympathetic reflexes to stressful challenge typically occurs. Sudden bradycardia can occur from shift in cardiac autonomic balance towards the parasympathetic system as evidenced in spectral analysis of heart rate variability, from activation of left ventricular mechanoreceptors from a sudden decrease in left ventricular volume (Bezold Jarisch reflex), or from increases in baroreflex activity [50].

Comparing spinal anesthesia with general anesthesia was not observed bradycardia [18,26]. Although it has been mentioned that high spinal anesthesia (T_2-T_4) can cause myocardial depression and decreased venous return [51], this was not observed in different series of studies during spinal anesthesia for laparoscopic [12-14,18,20,26,27,35,41,45,49].

Shoulder Pain

Shoulder-tip pain from diaphragmatic irritation by CO_2 and shivering can occur during surgery. The shoulder pain arising from C_5 dermatome also required high level of spinal blockade or increased amount of supplementary sedation. Sometimes, this phenomenon can be severe enough to result in conversion to general anesthesia [13]. It was reported right shoulder pain incidence of 20% [26] and 13% [35] an incidence of requiring i.e. fentanyl Also in a recent study by others [18] the shoulder pain incidence was 47%. In the study, local irrigation of the right diaphragm with lidocaine 2% 10 mL decreased right shoulder pain incidence to 20% and 17% in thoracic spinal group and lumbar spinal group, respectively, and pain was relieved successfully with 50 mg or 100 mg fentanyl [49]. In 3,492 patients undergoing spinal anesthesia for laparoscopic cholecystectomy the incidence of shoulder pain was 12.29%, with no need for conversion in any patient [41]. Shoulder pain observed in several studies [18,26,27] did not attend requiring conversion to general anesthesia. In a two recent meta-analysis studying the use of local anesthetic in laparoscopic surgery showed that there are no reports of toxicity [42,46]. The authors conclude that the use of intraperitoneal local anesthetic courses with significant reduction in postoperative pain [46].

Respiratory Effects

Hypercarbia observed during laparoscopic procedures is the result of peritoneal absorption of CO_2, ventilatory effects of tension pneumoperitoneum and surgical positioning. The most important factor appears to be peritoneal CO_2 absorption. The main debatable point, however, seems to be the status of respiratory parameters among the two modes of anesthesia during laparoscopic surgery. In this context, as a general overview, it can be stated that a spontaneous physiologic respiration during spinal anesthesia would always be better than an assisted respiration as in general anesthesia. The potentiality of intubation and ventilation-related problems, including an increase in the mechanical ventilation to achieve an adequate ventilation pressure, exists during general anesthesia, as compared to spinal anesthesia [15]. In addition, pulmonary function takes 24 hours to return to normal after laparoscopic surgery is performed under general anesthesia [52]. However, the observations are not uniform and conflicting reports of respiratory parameter alterations under regional and general anesthesia are present. It was been documented greater increase in $PaCO_2$ after the CO_2 pneumoperitoneum when the patient was under general anesthesia, as compared to when the patient was breathing spontaneously [53]. On the other hand, the authors [54] reported a significant arterial blood-gas alteration during epidural anesthesia, while others [17] concluded that epidural anesthesia for laparoscopy does not cause ventilatory depression. Even in various series, none of the patients had any significant variation of PaO_2 or $PaCO_2$ during the surgery under spinal anesthesia [12-14,18,20,26,27,35,41,45,49].

Nausea and Vomiting

Postoperative nausea and vomiting are relatively common after laparoscopic colecystectomy under general anesthesia [55], is becoming a serious problem, requiring the use of antiemetics in 50% of patients [56] and may delay hospital discharge [57]. The incidence of nausea and vomiting of 2.29% [41], 2.9% [18], 3.5% [27] was low during spinal anesthesia. The surgical technique of laparoscopic cholecystectomy was not different in spinal anesthesia compared to general anesthesia. Thus, the low incidence of nausea and vomiting seems to be related to the spinal approach. Following completion of the procedure, complete evacuation of CO_2 is mandatory to limit problems with post-operative pain and nausea/vomiting.

Surgical Time

Surgical time, considered the time of induction of general anesthesia or spinal anesthesia was the same and turned around 60 minutes [18]. When comparing high-dose and lumbar puncture with low-dose and thoracic puncture, the same result occurred [27]. However, the inflation time of CO_2 in patients in both series was about 35 minutes [18,27].The surgical time for LC under SA was 16 and 21.4 minutes, as compared to an operative time of 18.2 and 24.1 minutes for LC done under GA in the elective and patients with acute cholecystitis [41].Thus, there was no difference in the operating time while operating under spinal anesthesia; rather the total anesthesia to wheeling out the patient time actually decreases appreciably when the patient is being operated on under spinal anesthesia because the intubation and extubation time of general anesthesia is saved. The time of surgery decreases appreciably when the patient is operated under spinal anesthesia, because of the time of induction of general anesthesia and extubation.

Sensitive and Motor Blocks

Resolution of block depends on the dose of the drug given. Recently, it was proposed to understand the physiology for performing spinal anesthesia [29]. It was explained that the use of hyperbaric solutions and placement in the supine position and cefalodeclive, there is a predominance of sensory roots block (posterior or dorsal) to the detriment of the motor roots (anterior). The use of head-down after the administration of the hyperbaric anesthetic was responsible for the differential between the sensorial blockade which lasted 4:18 ± 0:42 hours, and the motor which lasted 3:01 ± 0:42 hours [18]. Comparing full doses with half the dose of hyperbaric bupivacaine with fentanyl [27], the duration of motor block was 3:06 ± 0:27 hours with 15 mg and 1:17 ± 0:15 hours with 7.5 mg . However, the duration of sensory block was 4:14 ± 0:36 hours with 15 mg and 3:06 ± 0:27 hours with 7.5 mg. This reflected a decrease a reduction in the duration of motor block in relation to sensory block of 45.9% with bupivacaine 15 mg and 33% with bupivacaine 7.5 mg [27]. Differences in the duration of motor and sensory block may be partly due to the smaller dose of bupivacaine and is consistent with previous reports [28].

The 50% reduction in the dose of hyperbaric bupivacaine provided faster recovery from motor block, enabling 60% of patients to move from the table to the stretcher unaided, making this technique excellent for ambulatory surgery [27]. The low-dose strategy may thus have an advantage in ambulatory patients because of the earlier recovery of motor and sensory function.

We were also impressed by the optimal anterior abdominal wall relaxation of up to the T_3-T_4 level and the conscious and receptive patients under spinal anesthesia. Another reason for our preferring spinal anesthesia was preventing the potential problems of general anesthesia. Thus, it was not a difficult decision for us to shift to SA for all our laparoscopic surgeries, and the insertion of the upper abdominal ports never caused any discomfort to the patient. This data confirms the superiority of the spinal anesthesia over general anesthesia in the control of postoperative pain.

Ambulation and Discharge

The mobilization and ambulation depend on the routine of each surgical team. In our department, patients under spinal anesthesia are encouraged to walk immediately after the regression of both blocks. The use of 7.5 mg hyperbaric bupivacaine and thoracic puncture attended with 60% of patients able to pass, without any help, from the operating table to the stretcher [27]. The presence of proprioception can be tested by asking the patient to identify the movements made in the big toes. Thus, if no motor block and the patient have this proprioception, he can ambulate immediately. Thus, the discharge can be programmed for the same day of surgery. The low-dose strategy may have an advantage in ambulatory patients because of the earlier recovery of motor and sensory function and earlier discharge.

Postoperative Pain

Laparoscopic cholecystectomy has rapidly become a popular alternative to open cholecystectomy, and is considered a cost-effective technique for the treatment of symptomatic cholelithiasis. Recently, the authors [58] reported the importance of achieving high-quality analgesia in the immediate postoperative period if one intends to maintain effective analgesia related to the regional block. The spinal anesthesia is a vital prerequisite for this success. Spinal anesthesia has some advantages compared with general anesthesia [18,26,27] including the patient being awake and oriented at the end of the procedure, less postoperative pain, and the ability to ambulate earlier than patients receiving general anesthesia.

In the postoperative period after spinal anesthesia, there was no restlessness, as is commonly seen after general anesthesia, and the patients were always receptive and more compliant to suggestions. A specific advantage of spinal anesthesia seems to be the decrease in the requirement of postoperative analgesia [41]. Theoretically, the addition of intrathecal fentanyl should improve the quality of the block and provide postoperative analgesia. It confirmed the superiority of spinal anesthesia in the control of pain in the immediate postoperative period when compared to general anesthesia [18]. Pain evaluated by the Visual Analogue Scale was significantly less severe in the spinal anesthesia group at 2, 4, and 6 hours compared with general anesthesia [18]. This difference can be attributed to the combination of several factors such as: non-performance of tracheal intubation, the presence of residual adequate analgesia (sensory block lasting more than motor block) in the early hours, the spinal fentanyl analgesia and potentially less surgical stress caused by minimal incisions.

In a recent meta-analysis of intraperitoneal local anesthetics for laparoscopic surgeries, some studies have shown a reduction in postoperative pain while others reported no benefit [46]. Some authors have suggested that administration of local anesthetics has an important role in the success of the technique.

Conclusions

Recently, the authors reported the importance of high quality analgesia is achieved in the immediate postoperative period, the obtained residual maintaining effective analgesia regional blockade [58]. Regional anesthesia is critical to this quality. Spinal anesthesia was used in 4,645 patients over the last 11 years [59]. In an other study with 3,492 patients spinal anesthesia was the technique of choice for laparoscopic cholecystectomy [41], a fact confirmed by comparing general anesthesia with high doses [18] or with low doses [27]. Spinal anesthesia provided evidence that can be an effective technique for laparoscopic elective, urgent and even morbid obesity, since it uses low pressure CO_2 pneumoperitoneum may be an alternative to general anesthesia. Spinal anesthesia decrease of bleeding in the operated area due to induce hypotension, bradycardia, and decreased venous return. Patients under general anesthesia often have additional problem of stomach insufflation result of mask ventilation, resulting in the need for tracheal intubation. With spinal anesthesia this problem was not observed in several studies. The cost of spinal anesthesia was 30% of general anesthesia [18].

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