The feasibility of laparoscopic general surgery under regional anaesthesia

Pratsas Konstantinos, MD, Georgopoulou Stauroula, MD, Bareka Metaxia, MD, Ieropoulos Chronis, MD, Flossos Andreas, MB BS DEAA, Vretzakis George, MD, PhD

ABSTRACT

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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 anaesthesia for laparoscopic general surgery, including patients with coexisting pulmonary disease who were deemed high risk for general anaesthesia. More recently, a limited number of studies showed the feasibility of the application of regional anaesthesia on healthy subjects. Nowadays, the properly controlled randomized studies addressing this issue remain limited, but their results show that the strong indication of general anaesthesia for laparoscopic general needs to be re-evaluated.

Sophisticated laparoscopic surgery has reduced postoperative morbidity, shortened hospital stays or even moved many procedures into the outpatient arena, and reduced overall costs. Laparoscopic procedures necessitate endotracheal intubation to prevent aspiration and respiratory embarrassment due to the induction of pneumoperitoneum. Increased intra-abdominal pressure and gas to be eliminated as load to the lungs are better managed under mechanical ventilation. Other major problems of interest for the anaesthesiologist include the effects of pneumoperitoneum on circulation, the venous gas embolism, the pathophysiological changes occurring in extremes of patient positioning and the extraperitoneal gas insufflation[1,2]. Pneumoperitoneum is not well tolerated in a patient who is awake during the procedure[3,4]. There is strong indication that laparoscopic procedures require general anaesthesia[5,6]. Thus it is not surprising, that in the era of minimally invasive medicine loco-regional anesthetic techniques have not gained popularity and acceptance for routine use as sole methods in laparoscopic general surgery procedures. At the present, local infiltration or regional anaesthesia have shown to be effective and safe in microlaparoscopy for simple, brief and precise gynaecologic procedures with minimal gas insufflation[2,7].

Anaesthesiology Clinic,
University Hospital of Larissa, Greece

Reports for laparoscopic general surgery under regional anaesthesia alone included patients with coexisting pulmonary disease, who are deemed high risk for GA. A small number of 6 patients operated for LC and unfit for GA due to chronic asthma and COPD was reported in 1998 from England[8] and 28 patients with COPD operated between 1998-9 was reported

in 2002 from Italy[9]. In both these series, surgeries were performed under EA without any reported anaesthetic complication. Similar studies exist for endoscopic repair of hernias under loco-regional anaesthetic techniques in patients unfit for GA (see below). For healthy patients, regional anaesthesia has been used in combination with GA for laparoscopic general surgery to extend the analgesic effect during the early postoperative period. The efficacy and safety of the combination of GA with epidural was tested in 40 patients randomized for LC under GA alone or in combination with EA[10]. The incidence of postoperative side effects was low in both groups and postoperative pain was controlled better in the group of the combination of GA with epidural. The use of intraoperative intravenous opioids was also minimized in the group of GA with epidural.

The strong indication of GA for laparoscopic general surgery is partly questioned by the successful application of loco-regional anaesthetics in patients unfit to have the procedure under GA. Is regional anaesthesia really contra-indicated for healthy patients coming for this kind of procedures? The presumed risk would be theoretically much lower for these patients in comparison with the patients included in the above mentioned reports. Are there any data supporting the safety of these techniques for subjects who, under minimally invasive surgical treatment, are expected to return quickly in their previous normal lives? The use of regional anaesthesia may be justified up to a degree for problematic patients, but is it the same with the healthy population?

Regional anaesthesia for laparoscopic cholecystectomy

Hamad and Ibrahim El-Khattary reported in 2003 for the first time the use of SA for LC in a small series of healthy patients using nitrous oxide pneumoperitoneum[11]. The feasibility of SA for LC with standard CO_2 and low-pressure pneumoperitoneum in healthy patients with symptomatic gallstone disease was tested in our Institution in 2005 and our findings were publicshed in 2006[12]. Encouraging results from this pilot study led a team of us to design a RCT to compare SA with GA in 100 healthy patients (50 in each group) for elective LC with a low-pressure pneumoperitoneum at a maximum of 10 mmHg[13]. Patients were followed up as in- or outpatients by an independent physician, blinded to type of anaesthesia. There was no conversion from SA to GA and peri-operative times (operation, PACU stay, discharge) and patient's satisfaction scores were comparable. Pain and supplementary opioids were signify-cantly lower during the postoperative hospital stay in patients having SA. In another recent study from Turkey, 29 ASA class I & II patients were prospectively recruited for LC under SA[14]. The operation was completed laparo-scopically on 26 patients, while 3 patients needed general anaesthesia due to severe right shoulder pain. In the half of the patients, low dose of intravenous opioids was administered to face severe right shoulder pain supplemented in the third of them by local washing of the right diaphragm with lidocaine. As satisfaction was stated by surgeons and patients, the authors concluded that SA for LC may be a treatment choice. In the same year, in a paper presenting 11 years of experience of a Centre in India, LC was performed under SA in 2,992 patients[15] and finally, in a more recent paper, the authors extended the period of observation to 12 years[16]. During this period of time LC was done under SA in 3,492 patients with a very low rate of conversion to GA (0.52%). Hypo-tension requiring support (20.05%), neck and/or shoulder pain (12.29%) and postural headache (5.9%) were the problems, that had to be faced more often in these patients. Comparing this group to 538 patients undergoing LC under GA, the authors noted less postoperative pain and vomiting. The authors concluded that SA is advantageous and should be the anaesthesia of choice.

Loco-regional anaesthesia for laparoscopic repair of hernias

Laparoscopic hernia repair is traditionally per-formed under GA to avoid the adverse effects of pneumoperitoneum in awake patients. It is of importance to mention, that repairs of hernias differ on account of pneumoperitoneum. Never-theless, even in totally extraperitoneal hernias,

peritoneal tears, visible or not, and pneumoperitoneum up to 40% or even higher may occur during endoscopic repair[17,18]. Although endoscopic totally extraperitoneal inguinal hernioplasty confers superior early outcomes compared to those of open repair, the requirement of general anaesthesia has been held as an argument against its application by opponents of laparoscopic surgery. Up to late '90s, GA and controlled ventilation comprised the accepted anaesthetic technique to reduce the increase in $PaCO_2$[6]. In a detailed cost analysis of extraperitoneal inguinal hernioplasty versus conventional repair performed in Holland in 1997, the reported rate of GA for the laparoscopic technique was 98.5%, far higher from the 40.2% accounting for the conventional repair[19].

Successful performance of surgery of this kind under loco-regional anaesthesia was reported for selected patients, who were medically unfit for GA[20-23]. In a report from USA, ten patients underwent their primary inguinal hernia repairs (3 of them had bilateral hernias) with laparoscopic technique under local anaesthesia[22]. There were no complications or conversion to GA. One year later, a report from the same Institution, with a nonrandomized prospective manner including only males with associated pulmonary disease and high risk for general surgery, compared 10 patients under local anaesthesia to 82 patients under GA[23]. The authors concluded that the laparoscopic repair under local anaesthesia represents an advantage in the repair of the inguinal hernia, particularly in the population where GA is contraindicated. In another report from USA, SA was used for the same operation in 35 patients with nitrous oxide as extraperitoneal gas. Although the occurrence of incidental peritoneal tears was high (63%), the resulted nitrous oxide pneumoperitoneum was well tolerated[18]. Preperitoneal herniorrhaphy was successfully performed in 36 patients under EA[24]. In a French study including 15 laparoscopic hernia repairs under local anaesthesia supported by hypnosis, only one was converted to GA[25]. In another prospective study from USA, 30 patients underwent successful extraperitoneal laparoscopic hernia repair under SA without conversion to GA[26]. Finally, in a study aimed to assess the likely uptake of laparoscopic surgery for inguinal hernias in Wales, from 67 consultant surgeons responding to a postal questionnaire 15% noted that they perform more than 90% of the procedures under local anaesthesia[27].

Reports for laparoscopic repair of intraperitoneal hernias under loco-regional anaesthesia alone for healthy individuals are scarce. In a study from Spain, 19 out of 23 patients underwent laparoscopic ventral hernia repair under SA while conversion to open surgery or GA was required in 4 patients[28]. In a feasibility study from our Institution, 25 ASA I or II patients underwent laparoscopic ventral hernia repair under SA[29]. In 9 cases the hernia was umbilical/para-umbilical, in 5 cases epigastric, and in 11 cases incisional. Conversion from spinal to general anaesthesia was not required. Most patients were discharged 24 hours after the operation, being satisfied with the anaesthetic procedure.

Recently, retrospective or observational studies in significantly sized populations have been published. The experience of over 8 years of using SA as the first choice in 480 patients for repair of extraperitoneal inguinal hernia with a high percentage been unilateral was reported in 2008 from India[30]. Strangulated and obstructed hernia patients were excluded, but irreducible hernia patients were included. Sedation was given if required, and the conversion to GA (only in 3 patients) was done in subjects not responding to sedation or with failure of SA. Postural headache was seen in 25 patients postoperatively and average time to discharge was 2.3 days. Almost simultaneously, the same group extended the period of observation to over than 11 years including 4,645 patients for various laparoscopic procedures from who a high percentage was for hernia repair[15]. The reported results were similar with only 0.01% of the patients requiring conversion to GA, 18.2% requiring support for hypotension and 12.2% experiencing neck or shoulder pain, or both. Lately, a retrospective analysis was reported also from India, carried out in 675 patients (1,289 hernias) in whom laparoscopic

total extraperitoneal hernia repair was performed[31]. A total of 659 patients operated under SA were compared to 16 patients under GA. Although the study was focused on the surgical result, the feasibility of the anaesthetic technique and the absence of major anaesthetic complications were elucidated.

To determine the feasibility and limitations of EA for laparoscopic total extraperitoneal inguinal hernia repair, 22 male patients were studied in 2002-03 in India and the results were published in 2007[32]. EA with 2% lignocaine was given via a lumbar epidural catheter, achieving a sensory level of T6. In 7 cases (31.9%) EA was converted to GA. The authors noted that prevention and management of pneumoperitoneum and subsequent shoulder-tip pain was the key to preventing these conversions. When sensory block was below T6, conversion rate was higher than 70%.

Despite these reports encouraging the application of loco-regional anesthetic techniques for laparoscopic repair of hernias, other investigators questioned their safety and efficacy in this kind of surgery. In a prospective study including 40 patients randomized to receive either combined spinal-epidural anaesthesia or GA there was no evidence that the anaesthesia regime used had any influence on the stress-parameters. Furthermore, most of the patients with regional anaesthesia showed severe agitation often accompanied by chest pain. The authors concluded that regional anaesthesia is not recommended for total extraperitoneal laparoscopic hernia repair[33]. Discontinuation of CSEA for total laparoscopic extraperitoneal inguinal hernia repair was done in an attempt to compare it with GA, because of the high conversion rate and of the major complications observed (severe bradycardia, cardiac arrest) [17].

Nerve blocking techniques may be of use as sole or adjuvant postoperative pain controllers in these operations. As percutaneous ilioinguinal nerve block is used for postoperative pain control after open groin hernia repair, some investigators suggest that in case of laparoscopic total extraperitoneal repair of groin hernia, laparoscopically guided ilioinguinal nerve block may be performed to improve postoperative comfort[34,35]. A small randomized study demonstrated that infiltration of suture fixation sites is effective in reducing early postoperative pain but not analgesic consumption following laparoscopic incisional and ventral hernia repairs[36].

COMMENT

To summarise, studies reporting anaesthetic technique other than GA for LC in healthy patients are scarce and most of them appear in the literature after 2003. The number of patients treated with SA is very limited and only one study is properly randomized-controlled. The studies of Sinha et al[15,16] are of importance as they present their significant experience in laparoscopic surgery under SA, but it is impossible to separate the healthy patients or to make a safe comparison with GA. Nevertheless, the feasibility of SA for these surgeries is displayed. It is of interest that all these reports addressing the use of SA for LC are originated from Departments of Surgery and are published in Journals of surgical interest. The studies for laparoscopic hernia repair start from the late 90's and enumerate less than 15. They are of observational or feasibility character and include in total less than 250 patients under loco-regional anaesthetic support. In the vast majority, hernias were extraperitoneal and the predominantly used anaesthetic technique was SA (6 studies). Local anaesthesia is reported as second in preference (3 studies) while EA and CSEA seem less preferable. Only recently, a limited number of retrospective reports in significantly large patient populations has appeared[15,31], with the endoscopic technique being supported solely by SA. Again, all these 18 reports addressing the use of loco-regional anaesthetic techniques for laparoscopic hernia repair are also originated from Departments of Surgery and are published in Journals of surgical interest.

Pain following laparoscopic cholecystectomy or hernia repair seems not to be a major problem, but as minimally invasive surgery aims in rapid and smooth recovery, this becomes a matter of interest. Almost all the above studies, imply-

cating RA in laparoscopic surgery, declare adequate postoperative pain control with or without adjuvant or supplemented therapy. In case of existence of a GA group for comparison, they report better pain control, particularly in the early postoperative period. Unfortunately, the lack of control in many, the retrospective or the non-blinded character of some and the fact that estimate postoperative pain from the analgesic drug consumption weaken the power of these statements. In the big sized series originating from India a routinely performed anaesthetic technique (SA) is compared to the technique, which is used under special circumstances (GA)[15]. Information about GA (for example kind and doses of opioids) is not provided. Nevertheless, in one study[13] postoperative pain control was defined as a primary end point and the methodology to assess it was properly blinded. The authors state that the size of the studied population was not enough for power of 80%. Theoretically, a difference favouring SA in postoperative pain control can be adopted as it could be attributed to a combination of the avoidance of discomfort, which is related to the endotracheal intubation, the presence of residual analgesic effect for few hours after the operation, and the potentially minimal stress response associated with SA[37].

More or less, the observed difference in PONV favouring loco-regional anaesthetic techniques can be commented similarly. For most of the studies, it is difficult to make comparisons and the measures taken, if any, to prevent PONV in case of GA are not described in detail. The actual rate of PONV for SA in an every day's clinical setting is questioned for one study[13], as the reported rate implicates an inserted nasogastric tube and administration of granisetron and ranitidine for all the patients belonging in SA group. In any case, the incidence of PONV is considered higher in GA, and in laparoscopic surgery often increases morbidity and can delay discharge from the hospital in a significant percentage of patients[2,7,38].

Shoulder and/or neck pain is a particular problem in laparoscopic surgery under loco-regional anaesthesia. Accidental, as it is in extraperitoneal surgeries, or not, pneumoperitoneum causes irritation of the diaphragm. The pain is mediated by high thoracic and even cervical spinal roots and it seems impossible to be blocked with regional anaesthesia alone. In the studies for LC, the rate of conversion from SA to GA due to intolerable pain ranged from zero to 10.3%[14], and pain requiring measures is reported from 20.0% to 44.8% for SA and 33.3% for EA[8]. In the studies for hernia repair, the presence of shoulder pain seems to be less, as most of the studies are for extraperitoneal hernias. Nevertheless, in one study with EA, the high conversion rate to GA (31.9%) was attributed in part to the shoulder pain[32]. The avoidance of peritoneal tears seems of extreme importance for these operations. For intraperitoneal hernias, even under a high spinal up to T_2 blockade, Bejarano Gonzales-Serna et al[28] reported a high conversion to GA rate (17.4%) and additional sedation for shoulder discomfort relief in 10.5% of the awake patients. Nevertheless, these data are not in accordance to Tzovaras et al[29], as they report no conversion. To lessen the problem, nitrous oxide for insufflations has been used, as it is considered a less irritating agent for the peritoneum[4,11,18]. The overall picture of the severity of shoulder pain and whether it impacts on an uneventful termination of surgery remain dark considering the gap between the studies not recommending regional anaesthetic techniques[17,36] and the results of others stating that under an occurrence of 12.3% it had never been a major problem[15].

Different techniques have been studied to decrease postoperative shoulder pain in laparoscopic procedures. Positioning, abdominal massage, passive drainage and suprahepatic suction of residual gas have all been attempted to decrease shoulder tip pain; these efforts have met with variable success[39,40]. The use of NSAIDS perioperatively also seems to attenuate the shoulder pain after laparoscopy[41]. Administration of intraperitoneal local anaesthetic (LA), either during or after surgery, is used by many surgeons as a method of reducing postoperative pain. A review by Boddy et al[42] does lend limited support to the use of intraperitoneal LA in laparoscopic cholecystectomy as part of a multimodal approach to pain mana-

gement. The technique seems to be safe and results in a statistically significant reduction in early postoperative abdominal pain. Moreover, there is some evidence to suggest that LA may be more effective, if used at a larger strength and if at least some is instilled before any dissection. Finally, the use of low-pressure pneumoperitoneum (bellow 10 mmHg) can also decrease the incidence and the severity of shoulder-tip pain in these procedures[43]. This technique may explain and the data from the study by Tzovaras et al[29], where no conversion of SA to GA was made due to severe shoulder pain discomfort.

For laparoscopic surgery, GA and controlled ventilation to reduce the increase in $PaCO_2$ and careful perioperative monitoring particularly for ASA III-IV patients were emphasised in older reviews. Among the factors affecting the total amount of the absorbed CO_2 are the gas pressure in the peritoneal cavity, the total free volume of the cavity, and the intermittent character and the duration of the application. Accidental or not, insufflation of CO_2 into extraperitoneal tissues also adds a probability of substantial CO_2 absorption. The uptake of exogenous CO_2 represents extra load to be exhaled by the lungs and in laparoscopic general or urologic surgery is well documented[44-47]. Values of rate of CO_2 absorption up to 40ml/min have been described. Later studies with adequate methodology found even greater values[48]. The degree of this absorption is probably associated with the kind of the procedure. In simple gynaecologic procedures its absolute value is low and they are routinely performed under RA[7,49]. The applied pressure is of significance for the rate of the absorption and together with time primarily affects the total uptake. Unfortunately, as the applied pressure was significantly higher than 10mmHg in all of the studies measuring absorption, its rate in pressures between 8-10mmHg cannot be commented. Furthermore, the rate of CO_2 elimination by the lungs to keep $PaCO_2$ within normal range under RA, where endogenous production is considered decreased, has not presently been studied. A healthy person, adopts easily his/hers pulmonary function when endogenous CO_2 production is increased, for example when climbing stairs and loco-regional techniques permit a normal response of spontaneous respiration to an increase of $PaCO_2$. In an article from Japan, a limited number of patients was studied for gynaecologic laparoscopy to compare GA and EA[50]. The authors suggested that during laparoscopy, ventilation could be well maintained by spontaneous breathing. They noticed that $PaCO_2$ increased significantly in the patients who were mechanically ventilated, but not in the patients breathing spontaneously.

Upper abdominal surgery, pneumoperitoneum and anaesthetic technique, all impact on lung mechanics and on functional variables of respiretory system. LC under GA resulted in less postoperative respiratory dysfunction than conventional cholecystectomy[51,52,53]. Postoperative atelectasis defined by chest X-ray was also in favor for LC. Nevertheless, in all these studies early postoperative pulmonary function tests were significantly worse compared to preoperative values even in the favorable LC. In laparoscopic surgery performed using GA, pulmonary function takes many hours or even days to return to normal[54]. It is explicable how data concerning pulmonary function during and after laparoscopic surgery under RA are scarce.

The need of GA-controlled ventilation became debatable as uncomplicated outcomes from laparoscopic general surgery under RA for patients with compromised pulmonary function were demonstrated in newer reports[8,9,20-23]. Healthy subjects, included in later reports, showed adequate homeostatic mechanisms to manage the exogenous CO_2 load.

As more and more studies prove the feasibility of laparoscopic procedures under RA, the time has come as anaesthesiologists to look deeper into the matter. It seems that the patients that will benefit the most from RA in laparoscopic procedures are the patients with the most health problems. It is those patients that we should try the most to protect from the disadvantages of GA and offer them at the same time the advantages of RA. In order to do so in a safe approach, we should first study the physio-

logical changes of laparoscopic procedures under RA in ASA I-II patients.

The impact of pneumoperitoneum on the breathing system of awake patients has to be studied. We still do not know how the human body reacts by itself to the extra CO_2 load. How much will the $PaCO_2$ rise in a spontaneously breathing awake patient and how will the breathing system react to that? We assume that the $PaCO_2$ will rise, but we do not know by how much, if the rise is clinically important, and how long will it take to come back to normal. The patient will probably increase the minute ventilation, but in what way? We lack studies which show if the respiratory rate or/and the tidal volume change and by how much. At this point we should also take into account the positioning of the patient. In LC the patient is positioned with the head up, but in laparoscopic hernia repair the patient is in the head down position. This may affect the ability of the breathing system to cope with the extra CO_2 load.

Another matter we know little about is how the pulmonary function tests are affected by RA in laparoscopic procedures compared to GA. We still do not know if we have a favorable result concerning the aggravation of the pulmonary function or the time it needs for a full recovery. At this point we should also consider the postoperative atelectasis. We already know that LC results into less postoperative atelectasis compared to conventional cholecystectomy. The new question now is if RA can further reduce atelectasis, if the reduction is clinically important, and the time needed to dissolve.

As anaesthesiologists we are also interested in which regional technique is more advantageous. The questions are many. Laparoscopic procedures held under SA or EA? Which technique is more comfortable for the patient? Which technique is preferred by the surgeon? Of course the issue of how high should be the sensory and the motor block is still open, with a lot of discussion around it to be made. Even pharmacological issues, such as the choice of the local anaesthetic, are still unaddressed.

CONCLUSION

Laparoscopic surgery has managed to reduce postoperative morbidity, shorten hospital stay and increase the day-surgery procedures. Although surgery made huge progress to that field, anesthesia remained unchanged for the majority of these cases. GA is the anaesthetic technique of choice until now, mainly because we thought that laparoscopic procedures cannot be made under RA due to the risk of aspiration and the respiratory embarrassment that the pneumoperitoneum leads to. The last years however, studies can be found in the literature supporting the feasibility of RA for laparoscopic general surgery cases. These data are encouraging enough, in order to think about changing our opinion about laparoscopic surgery and RA. It is time for us anaesthesiologists to stop ignoring this new era. It is time to study and bring the benefits of RA to our patients, who will undergo laparoscopic surgery. Before this time comes, however, there are a lot of questions to be answered and we need more studies in order to get the most of RA in laparoscopic surgery.

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abbreviations and acronyms

COPD	chronic obstructive pulmonary disease
CSEA	combined spinal – epidural anaesthesia
EA	epidural anaesthesia
GA	general anaesthesia
LC	laparoscopic cholecystectomy
LMA	laryngeal mask airway
NSAID	non-steroid anti-inflammatory drugs
PONV	postoperative nausea and vomiting
RA	regional anaesthesia
RCT	randomized control study
SA	spinal anaesthesia

ΕΠΙΚΟΙΝΩΝΙΑ:
George Vretzakis, UNIVERSITY HOSPITAL OF LARISSA, Mezourlo, Larissa 41110, GREECE
tel.: (Greece) 2413502952, mobile: 6946215721, fax: (Greece) 2410670245
e-mail: gvretzakis@yahoo.com

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