ORIGINAL ARTICLE

Prospective non-randomized comparison of open versus laparoscopic transabdominal preperitoneal (TAPP) inguinal hernia repair under different anesthetic methods

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Abstract

Purpose   To compare prospectively open vs. laparoscopic transabdominal preperitoneal (TAPP) inguinal hernia repair performed under different anesthetic methods.

Methods   A total of 175 patients scheduled for unilateral inguinal hernia repair were assigned to one of the following groups: (i) open repair under local anesthesia, (ii) open repair under regional anesthesia, (iii) open repair under general anesthesia, and (iv) TAPP under regional anesthesia. Immediate postoperative pain was the main outcome measured. Short- and long-term complications and the degree of patient satisfaction were also assessed.

Results   Transabdominal preperitoneal repair under regional anesthesia yielded the lowest pain scores, whereas open repair under general anesthesia yielded the highest pain scores ($P < 0.05$). Open repair under local or general anesthesia had a lower urinary retention incidence than the spinal groups ($P < 0.05$). Chronic pain incidence was lower for the TAPP group (P 0.003). There were no differences in other short- and long-term complications.

Conclusion   Transabdominal preperitoneal repair under spinal anesthesia proved superior to open repair performed under different types of anesthesia in terms of immediate (24-h) postoperative pain. The method of anesthesia might have contributed more to this favorable outcome than the surgical technique itself, but at the cost of a high urinary retention incidence. The incidence of chronic pain was lower after TAPP repair.

Introduction

Inguinal hernia repair remains challenging for the surgeon because of its short- and long-term complications such as infection and chronic pain, and the fear of its recurrence. Inguinal hernia repair has evolved from the old herniorrhaphy techniques to tension-free repair using mesh and, finally, laparoscopic approaches. Results of studies evaluating these techniques, in terms of immediate postoperative complications, recurrences, and chronic pain, established tension-free mesh repair as "the gold standard" in open inguinal hernia repair [1, 2]. Laparoscopic inguinal hernia repair has also proved efficient, becoming a valuable alternative offering the advantages of minimally invasive surgery [4, 5].

The combination of these surgical techniques with the available anesthetic alternatives creates a blend of procedures with different characteristics. Traditionally, laparoscopic inguinal hernia repair is carried out under general anesthesia; however, studies evaluating the feasibility of performing laparoscopy under spinal anesthesia suggest its safety and efficacy [8, 9]. Either the transabdominal preperitoneal (TAPP) or the totally preperitoneal (TEP) approach can be performed under spinal anesthesia without compromising the principles for painless, safe, and curative surgery. On the other hand, open inguinal hernia repair can also be successfully performed under local, spinal, or general anesthesia.

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We conducted this study to evaluate prospectively two inguinal hernia repair surgical procedures; namely, open and TAPP repair, performed under different anesthetic techniques within the context of the routine clinical practice in our unit. Immediate postoperative pain, defined as pain during the first 24 h, was the main outcome assessed, while short-term complications such as urinary retention, seroma, hematoma, and infection and long-term complications such as recurrence and chronic pain were also recorded.

Material and methods

Internal board approval and ethics committee permission were obtained prior to the initiation of this prospective study. The subjects were 175 patients scheduled for unilateral primary surgical repair of inguinal hernia. Patients with scrotal, recurrent, bilateral, strangulated, or incarcerated hernias were excluded from the study.

In our daily clinical practice, at the Department of Surgery, University Hospital of Larissa, open inguinal hernia repair is performed under three different types of anesthesia: local, regional, or general. Although general anesthesia is the gold standard anesthetic modality used for laparoscopic hernia repair, over the last few years we have routinely offered spinal anesthesia for TAPP repair [8]. Ultimately, the decision about the surgical and anesthetic technique is at the patient's discretion after a detailed informative discussion with the surgeon.

Anesthetic techniques

Regardless of the operative technique, all patients received a standard sedation protocol with 50 mg pethidine I.M. and premedication with 0.1 mg atropine I.V. prior to the operation. Local anesthesia was performed with the infiltration of 40 ml of lidocaine 1 % at the site of incision (subcutaneous fat and intradermic level) and then at deeper layers, underneath the aponeurosis of the external oblique inside the inguinal canal. For spinal anesthesia, the patient was placed in the right lateral decubitus position and a 25-gauge pencil-point spinal needle was introduced into the subarachnoid space at the L2–L3 intervertebral space, under aseptic conditions. After free flow of cerebrospinal fluid was confirmed, 3 mL of hyperbaric bupivacaine 0.5 %, 0.25 mg of morphine, and 20 µg of fentanyl were injected intrathecally. Patients were monitored continuously during the operation by both clinical observation and intensive hemodynamic monitoring. Standard general anesthesia with endotracheal intubation was the last anesthetic option: anesthesia was induced with propofol (2–3 mg/kg), fentanyl citrate (5 µg/kg), and atracurium

besylate (0.5 mg/kg) and maintained with sevoflurane 1–2 % and propofol (2 mg/kg/h). After tracheal intubation, the lungs were ventilated with 50 % oxygen in air using a semiclosed circle system. Ventilation was controlled with a tidal volume of 8–10 mL/kg and the ventilatory rate was adjusted to maintain a $PaCO_2$ value of 35–40 mmHg. Residual neuromuscular block was antagonized with 25 mg of neostigmine methylsulfate and 1 mg of atropine sulfate at the end of surgery.

Surgical techniques

Open repair

Through a 5–8 cm skin incision, the external oblique aponeurosis was incised and we carefully aimed to identify and preserve the ilio-inguinal and ilio-hypogastric nerves. The spermatic cord was carefully dissected free from the hernia sac, which was always reduced. The inguinal ligament was dissected toward the pubis up to the anterior superior iliac spine. A wide dissection of the conjoined tendon and the rectus muscle aponeurosis was performed up to the pubic tubercle to create the space required to spread out the mesh. Direct or indirect inguinal hernias were treated with the same principles. An absorbable plug (Gore BIO A hernia plug®) was placed in the internal ring of the inguinal canal preperitoneally and fixed with one or two absorbable sutures. This maneuver was common in all open repairs irrespective of whether the hernia was direct or indirect. An expanded polytetrafluoroethylene (e-PTFE) non-absorbable patch (GORE-TEX® Soft Tissue Patch) was placed into the inguinal canal and secured in place with non-absorbable sutures. Finally, the external oblique aponeurosis was closed and refashioned, superficially to the spermatic cord, with a continuous non-absorbable suture.

Laparoscopic TAPP repair

Following the induction and analgesic effect of spinal anesthesia, the patient was placed supine on the operating table with the arms to the side and in a 10°–20° Trendelenburg position. A 10 mm optical trocar was inserted at the umbilicus using the open Hasson technique and laparoscopy of the abdominal cavity was performed. Two additional 5 mm trocars were placed under direct vision in the mid-clavicular line at the level of the umbilicus. The preperitoneal space was entered by incising the peritoneum transversely from the region of the superior iliac spine laterally, to the median umbilical ligament medially, superiorly to the hernia defect. Peritoneal flaps were then prepared and the hernia sac was dissected free from the spermatic cord structures. We dissected medially to the
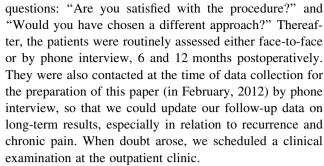
symphysis pubis and inferiorly to Cooper's ligament. Titanized, ultra-lightweight polypropylene 15 × 10 cm mesh (Timesh®–GfE Medizintechnik GmbH, Nuernberg, Germany) was then inserted to cover all three possible defects; namely, the internal ring, Hasselbach's triangle, and the femoral ring of the inguinal–femoral area. The upper part of the mesh was fixed in place with tacks (Protack®–Covidien, USA). The peritoneum was closed over the internal aspect of the mesh.

According to the available surgical and anesthetic alternatives and our unit's routine policy on inguinal hernia repair, patients were assigned to one of the following categories: open repair under local anesthesia (OL), open repair under spinal anesthesia (OS), open repair under general anesthesia (OG), and laparoscopic TAPP repair under spinal anesthesia (LS). We aimed to allocate a minimum of 50 patients to each group for the preliminary analysis. Although we did not perform a power analysis, the sample size in this study was based on the estimated inguinal hernia case volume within the current setting. 50 patients in each category were adopted for a preliminary analysis, but with the intention to expand this number should the study end points not be fulfilled. All operations were performed according to the same predetermined principles from the study design by three specialized surgeons with many years of experience in open and laparoscopic (TAPP) hernia repair. Any intraoperative incidents, especially those related to the method of anesthesia and/or the pneumoperitoneum in the laparoscopic group, such as changes in cardiopulmonary function and hemodynamic status, shoulder pain, discomfort, and nausea, were recorded.

Immediate postoperative pain, defined as pain during the first 24 h after surgery, was the main outcome assessed in this study. Patients were asked to fill in a visual analog score (VAS)-based questionnaire 4, 12, and 24 h postoperatively. The VAS score was assessed at rest and during stress induced by asking the patient to cough. Antibiotic prophylaxis was not given routinely and only patients who required Foley catheter placement received a single dose of a second-generation cephalosporin. All patients routinely received low molecular weight heparin subcutaneously and proton pump inhibitors intravenously. A standard postoperative analgesic protocol was followed with oral paracetamol 500 mg every 6 h, and intravenous parecoxib sodium 40 mg twice a day. Analgesics were given on demand when the standard protocol did not achieve adequate pain control and this was recorded.

All patients were followed up as outpatients 10–15 days after their operation to check for signs of any short-term complications such as urinary retention, seroma, hematoma, infection, and orchitis. We also estimated their degree of satisfaction with the procedure by asking two factual questions: "Are you satisfied with the procedure?" and "Would you have chosen a different approach?" Thereafter, the patients were routinely assessed either face-to-face or by phone interview, 6 and 12 months postoperatively. They were also contacted at the time of data collection for the preparation of this paper (in February, 2012) by phone interview, so that we could update our follow-up data on long-term results, especially in relation to recurrence and chronic pain. When doubt arose, we scheduled a clinical examination at the outpatient clinic.

Statistical analysis was carried out using SPSS® software (Statistical Package for Social Sciences) version 15. One-way analysis of variance (ANOVA) followed by Bonferroni's post hoc comparisons tests were performed to compare the mean values ± standard deviation of the VAS score (4, 12, and 24 h postoperatively, either at rest or under stress). The Fisher's exact test (two tailed) was used to compare differences in the incidences of each postoperative complication. A result was considered significant when the P value was <0.05.

Results

Overall, 175 patients who fulfilled the inclusion criteria were included in this study. Fifty patients underwent open inguinal hernia repair under local anesthesia (OL), 50 underwent open repair under spinal anesthesia (OS), 25 underwent open repair under general anesthesia (OG), and 50 underwent laparoscopic TAPP inguinal hernia repair under spinal anesthesia (LS). Table 1 summarizes the demographics as well as the hernia characteristics in each group. There were no conversions to the followed technique from either the surgical or anesthetic viewpoint. Only minor intraoperative incidents were encountered, notably shoulder pain and/or discomfort (18 %—9 patients) during the laparoscopic approach, which was managed successfully with pharmaceutical interventions alone. Bradycardia was the main adverse incident in the open repair groups, affecting 19 (15.2 %) patients and was successfully reversed with atropine.

Tables 2 and 3 show the mean ± standard deviation (SD) VAS scores for the operative groups, at rest and under stress, respectively. Table 4 compares the mean VAS scores recorded in the four groups. The comparison revealed clear superiority of the laparoscopic under spinal anesthesia arm of the study in relation to postoperative pain. Only in the 4th postoperative hour did patients operated on under spinal anesthesia, either open or laparoscopically, exhibit relatively comparable pain scores ($P < 0.05$). Furthermore, spinal anesthesia proved superior to the other anesthetic methods for open repair when postoperative pain was the outcome of interest. Conversely,

Table 1 Patient demographics and hernia characteristics in each group

	Open local n:50	Open spinal n:50	Open general n:25	LAP spinal n:50
Age (mean ± SD)	55.86 ± 11.83	56.04 ± 13.44	61.28 ± 11.42	57.50 ± 10.94
Gender ratio (male:female)	47:3	47:3	21:4	44:6
ASA (I–IV)	1.36 ± 0.53	1.52 ± 0.61	1.48 ± 0.51	1.34 ± 0.48
Side (right:left)	25:25	23:27	9:16	23:27
Type (indirect:direct)	36:14	33:17	18:7	37:13

Table 2 Mean ± standard deviation VAS scores at rest 4, 12, and 24 h postoperatively for all surgical categories

	Open local n:50	Open spinal n:50	Open general n:25	LAP spinal n:50
4 h	3.84 ± 1.39	1.32 ± 1.10	5.08 ± 1.61	0.92 ± 0.63
12 h	4.16 ± 1.27	1.46 ± 1.07	5.36 ± 1.58	0.82 ± 0.72
24 h	3.78 ± 1.25	1.62 ± 1.14	5.04 ± 1.31	0.82 ± 0.77

Table 3 Mean ± standard deviation VAS score under the stress of coughing 4, 12, and 24 h postoperatively for all surgical categories

	Open local n:50	Open spinal n:50	Open genera n:25	LAP spinal n:50
4 h	5.14 ± 1.90	1.84 ± 1.13	6.84 ± 1.60	1.50 ± 0.81
12 h	5.40 ± 1.60	2.32 ± 1.39	6.56 ± 1.53	1.42 ± 0.97
24 h	4.78 ± 1.69	2.48 ± 1.31	6.00 ± 1.26	1.46 ± 0.84

patients who underwent open repair under general anesthesia had the higher recorded pain scores. These results are expressed in terms of statistical significance at all postoperative time points when pain was assessed (Table 4). Nine (36 %) of the patients in this group requested analgesics outside the standard protocol, which was more than in any other group. Conversely, only three (6 %) patients from the open repair under local anesthesia group required extra analgesics. No extra analgesic administration was recorded for the patients operated on under regional anesthesia either open or laparoscopically, indicating that pain control was satisfactory with the standard analgesic protocol.

Urinary retention manifested as lower abdominal pain and was a common short-term complication in the immediate postoperative period. Adequate relief was achieved by temporary (overnight) urinary bladder catheterization with a Foley catheter in all cases. Table 5 summarizes the short- and long-term complications in the four groups. The incidences of urinary retention for the laparoscopic and open repair under spinal anesthesia groups were 36 and 32 %, respectively (P 0.833). The open repair under local or general anesthesia groups had significantly lower incidences of urinary retention (16 and 12 %, respectively)

than the spinal groups ($P < 0.05$). At the scheduled examination, 10–15 days after the procedure, the vast majority of patients reported being pleased with their procedure. Only three patients who underwent open hernia repair under local anesthesia admitted that they would have chosen a different anesthetic and/or surgical option. There were no differences in the incidence of seroma formation, wound infection, orchitis, or hematoma among the four groups.

In the long term, three (6 %) patients from the laparoscopic group and 4, 6 and 12 % from the open local, spinal, general groups, respectively, were lost to follow-up. After a median follow-up period of 30 months (range 12–52 months), there were no reports of chronic pain in the laparoscopic repair group. Compared with the reported chronic pain incidence of all the open repair groups (17/125 patients), this result was significant (P 0.0036). Most of the patients with chronic pain reported a constant dull groin pain and/or a "pins and needles" sensation, especially during intense physical exercise, although they reported that this could be relieved with over-the-counter pain killers. There were no differences in the incidence of recurrences (P 1.000) or rigidity/foreign body sensation (P 0.196) between the laparoscopic and the open repair technique.

Discussion

Inguinal hernia repair has evolved remarkably during the last decade. The introduction of laparoscopic techniques to the existing open approaches raised questions regarding the most appropriate technique, but the answers were not as obvious as in other fields of general surgery where laparoscopic surgery clearly dominated. Each procedure appears to have advantages and disadvantages, which is compounded further when all the available anesthetic alternatives are included in the assessment.

Open inguinal hernia repair is currently a procedure that can be carried out under local anesthesia with minor sedation, as done routinely in many centers. The use of local anesthetic agents alone and the avoidance of more interventional and complicated anesthetic procedures

Table 4 Comparison of mean VAS scores among the four groups at rest (upper) and under stress (lower) 4, 12, and 24 h postoperatively (one-way ANOVA post hoc tests with Bonferroni correction)

	OL 4h	OL 12h	OL 24h	OS 4h	OS 12h	OS 24h	OG 4h	OG 12h	OG 24h	LS 4h	LS 12h	LS 24h
OL 4h				S			S			S		
OL 12h					S			S			S	
OL 24h						S			S			S
OS 4h	S						S			NS		
OS 12h		S						S			S	
OS 24h			S						S			S
OG 4h	S			S						S		
OG 12h		S			S						S	
OG 24h			S			S						S
LS 4h	.S			NS			S					
LS 12h		S			S			S				
LS 24h			S			S			S			

S significant (*P* value <0.05), NS not significant (*P* value >0.05)

render this surgical method attractive and easily reproducible. However, it cannot be generalized, as many postoperative parameters should be taken into account to label any procedure as the "gold standard" of treatment, from both anesthetic and surgical viewpoints. Spinal and general anesthesias also represent valid alternative anesthetic modalities for open inguinal hernia repair, although their indications are not strictly defined. Laparoscopic surgery for inguinal hernia repair was introduced to offer patients the advantages of minimally invasive surgery. Increased costs and fears about the possible failure of the procedure for technical reasons are counterbalanced by what published reports promise: namely, faster return to normal activities and mitigation of long-term complications such as chronic pain and numbness [1–11]. The recently proposed laparoscopic hernia repair under spinal

Table 5 Short- and long-term complications in all surgical categories and the statistical comparison (P value) of each complication of the two operative approaches (open vs. laparoscopic)

	Open local n:50	Open spinal n:50	Open general n:25	LAP spinal n:50	P value
Short-term complications					
Urinary retention	8 (16 %)	16 (32 %)	3 (12 %)	18 (36 %)	0.057
Seroma	3 (6 %)	1 (2 %)	2 (8 %)	0	0.184
Wound infection	2 (4 %)	1 (2 %)	0	0	0.558
Hematoma	3 (6 %)	2 (4 %)	1 (4 %)	1 (2 %)	0.674
Orchitis	1 (2 %)	0	0	1 (2 %)	0.491
Long-term complications					
Chronic pain	7 (14 %)	6 (12 %)	4 (16 %)	0	0.003
Rigidity/numbness	7 (14 %)	6 (12 %)	5 (20 %)	3 (6 %)	0.196
Recurrences	2 (4 %)	1 (2 %)	2 (8 %)	2 (4 %)	1.000

anesthesia seems innovative [8, 9] and general anesthesia should no longer be considered a prerequisite for laparoscopic techniques. Both TEP and TAPP have been successfully performed under spinal anesthesia in studies that also demonstrated their safety and efficiency [13, 14]. Incidents such as hypotension or bradycardia during the procedure were common; however, they were reversed with intravenous volume overload or atropine, respectively [9, 10, 13, 14]. Indeed, a few conversions were recorded [9, 10, 13, 14]. It remains to be proven if this surgical and anesthetic combination is of benefit to the patient.

In this study, we tried to evaluate, prospectively, the surgical and anesthetic techniques available for inguinal hernia repair within the context of our daily clinical practice. We focused on the comparison of clinical parameters, such as postoperative pain and other short- and long-term complications. We also assessed changes in the biochemical markers of systemic immune response, such as interleukins and acute phase reactants, although this is not part of the present paper. The lack of randomization and selection bias represents the limitation of this study. The fact that the patient's preferences played a key role in the final decision about the procedure explains the unequal allocation among the four groups. When the predetermined number of patients (50) in each category was reached, the patients who chose a certain operative arm were excluded from the study. Patients were especially reluctant to undergo open inguinal hernia repair under general anesthesia, which explains the small number of patients in this category. However, significance was reached for the study end points for all comparison categories, rendering patient selection difficulties a matter of less importance.

In this study, we used e-PTFE, a more sophisticated mesh type than the standard polypropylene mesh, for open inguinal hernia repair. The logistics of the current medical setting as well as insurer's specifications were the main arguments for this approach. Certainly, unifying the

materials used in the two surgical approaches would be a more objective approach and could neutralize parameters arising from the different materials used, which could add bias. However, what at first seems a limitation, such as the use of different mesh materials in the two approaches, could practically take open hernia repair one step forward. It is hypothesized that using an inert material within the global standards, such as e-PTFE, would increase in vivo softness and conformability, improving long-term repair results, especially chronic pain and foreign body sensation. Generally, studies that evaluate the efficiency of using this mesh for inguinal as well as ventral hernia repairs have reported acceptable, if not better, long-term results than those for standard polypropylene [15, 16]. Our initial experience favored this approach for open hernia repair in our department. On the other hand, titanized lightweight polypropylene was the mesh material chosen for laparoscopic repair. We think that this heterogeneity in materials, while lacking the desired objectivity, could raise the potential and limit the weaknesses of open repair in the long term when compared with its laparoscopic alternative.

According to our data, laparoscopic inguinal hernia repair under spinal anesthesia yielded the lowest pain scores ($P < 0.05$). This could be attributed to a combination of both surgical and anesthetic parameters. Spinal anesthesia proved superior to the other anesthetic techniques for minimizing postoperative pain after open repair. It seems that the analgesic effect of spinal anesthesia continues during the early postoperative period, offering a relatively pain-free recovery. None of these patients suffered spinal anesthesia-related headache. The use of a 25-gauge pencil-point spinal needle and generous intravenous fluid administration might be responsible for this favorable, but surprisingly unexpected outcome. On the other hand, the lack of peripheral nerve block in general anesthesia is reflected in increased postoperative pain and the need for extra analgesics. Finally, local anesthesia

seems to exert a short-term analgesic effect during the first 2–3 h, but this result was not consistent or measurable in the 4th postoperative hour pain evaluation.

Regarding short-term complications, laparoscopic surgery under spinal anesthesia was associated with a higher incidence of postoperative urinary retention (36 %) among the four groups of the study ($P < 0.05$), something already reported and underlined by our group [8]. This can be justifiably considered as the major drawback and limitation of the method. Possible explanations include: the effect of spinal anesthesia on bladder tone, dissection in the vicinity of the bladder, and the population characteristics of relatively old men with a hypertrophic prostate. Recently, we have focused our efforts on reducing this worrisome complication on the optimal composition of the anesthetic mixture (with less morphine) injected in the subarachnoid space with impressive preliminary anecdotal results.

Generally, the vast majority of patients declared satisfaction with their procedure. Quantitative data were not available as only two simple straightforward (yes/no) questions were asked at the scheduled follow-up, approximately 2 weeks after the procedure. Only three patients from the open repair under local anesthesia group admitted that they would have chosen an alternative procedure. Interestingly, patients submitted to laparoscopic repair under spinal anesthesia, the group with the highest incidence of postoperative urinary retention and intraoperative discomfort, appeared pleased with the outcome of that procedure. Certainly, a detailed assessment within a quality of life-focused study, using a validated patient satisfaction questionnaire would be a more objective approach.

The long-term complications we focused on were recurrence, chronic pain, rigidity, and numbness. The incidence of chronic pain was significantly lower in the laparoscopic arm (0 vs. 13.6 %, $P = 0.0036$), but there were no significant differences in recurrences and the annoying foreign body sensation/rigidity between the open and laparoscopic surgical techniques at a median follow-up of 30 months. The reported follow-up period of 30 months represents the median value of a wide-ranged distribution (range 12–52), rendering definite conclusions and generalizations about long-term results unreliable.

Generally, after open mesh hernia repair, approximately 11 % of patients suffer from chronic pain and one-third of these patients are limited in daily activities [17]. The magnitude of the problem is depicted by the fact that even surgical intervention for mesh removal or neurectomies has been proposed to alleviate chronic pain [18]. Altering mesh characteristics by using lightweight polypropylene or even composite meshes, as well as advances in surgical techniques mainly through the laparoscopic approach, have set the stage for optimization of the long-term results [1–19]. Aligned in this direction, we tried to limit to a minimum

the number of staples we used, apply the staples only to the anterior mesh fixation, and avoid inadvertent nerve injury during the laparoscopic repair to prevent chronic pain. Furthermore, the mesh materials used in the laparoscopic as well as in the open arm were in accordance with modern surgical trends: namely, a titanium-coated ultra-lightweight polypropylene mesh and an expanded-PTFE mesh, respectively. Although the variety of material indicates differences in mechanisms of action and biocompatibility, the common denominator is the limited local inflammatory reaction. The latter has been reliably associated with a decreased incidence of chronic pain [20–23].

The results of our four-arm trial demonstrated TAPP repair under spinal anesthesia as the most efficient procedure for minimizing postoperative pain. This attractive approach incorporates a minimally invasive surgical modality, laparoscopy, and its anesthetic counterpart, spinal anesthesia. The method of anesthesia, namely spinal anesthesia, probably contributed more to this favorable outcome after TAPP than the surgical technique itself. The intrathecal administration of morphine during spinal anesthesia seems to have an extremely effective postoperative analgesic result, but at the cost of a high risk of urinary retention. Although minimizing postoperative pain is crucial to the patient's satisfaction, the increased incidence of urinary retention associated with this form of anesthesia makes us hesitant to adopt this procedure in its current form over open repair under different types of anesthesia. The incorporation, in the final analysis, of data from the serum stress markers and statistical comparison will probably elucidate this dilemma from the molecular point of view. A prospective controlled randomized trial comparing spinal and conventional general anesthesia for laparoscopic TAPP repair is currently underway in our department to elucidate the obscurities regarding the optimal method of anesthesia for the approach.

In conclusion, our results showed laparoscopic TAPP inguinal hernia repair under spinal anesthesia to be superior to open tension-free repair performed under different types of anesthesia in terms of immediate postoperative and chronic pain, but with the notable limitation of a high incidence of urinary retention.

References

1. McCormack K, Scott NW, Go PM, Ross S, Grant AM; EU Hernia Trialists Collaboration. Laparoscopic techniques versus open techniques for inguinal hernia repair. Cochrane Database Syst Rev. 2003;(1):CD001785.
2. Pokorny H, Klingler A, Schmid T, Fortelny R, Hollinsky C, Kawji R, et al. Recurrence and complications after laparoscopic

versus open inguinal hernia repair: results of a prospective randomized multicenter trial. Hernia. 2008;12(4):385–9.

3. Liem MS, van der Graaf Y, van Steensel CJ, Boelhouwer RU, Clevers GJ, Meijer WS, et al. Comparison of conventional anterior surgery and laparoscopic surgery for inguinal-hernia repair. N Engl J Med. 1997;336(22):1541–7.

4. Hamza Y, Gabr E, Hammadi H, Khalil R. Four-arm randomized trial comparing laparoscopic and open hernia repairs. Int J Surg. 2010;8(1):25–8.

5. Wake BL, McCormack K, Fraser C, Vale L, Perez J, Grant AM. Transabdominal pre-peritoneal (TAPP) vs totally extraperitoneal (TEP) laparoscopic techniques for inguinal hernia repair. Cochrane Database Syst Rev. 2005;(1):CD004703.

6. McCormack K, Wake B, Perez J, Fraser C, Cook J, McIntosh E et al. Laparoscopic surgery for inguinal hernia repair: systematic review of effectiveness and economic evaluation. Health Technol Assess. 2005;9(14):1-203, iii-iv.

7. Perko Z, Rakić M, Pogorelić Z, Družijanić N, Kraljević J. Laparoscopic transabdominal preperitoneal approach for inguinal hernia repair: a five-year experience at a single center. Surg Today. 2011;41(2):216–21.

8. Zacharoulis D, Fafoulakis F, Baloyiannis I, Sioka E, Georgopoulou S, Pratsas C, et al. Laparoscopic transabdominal preperitoneal repair of inguinal hernia under spinal anesthesia: a pilot study. Am J Surg. 2009;198(3):456–9.

9. Sinha R, Gurwara AK, Gupta SC. Laparoscopic total extraperitoneal inguinal hernia repair under spinal anesthesia: a study of 480 patients. J Laparoendosc Adv Surg Tech A. 2008;18(5):673–7.

10. Ismail M, Garg P. Laparoscopic inguinal total extraperitoneal hernia repair under spinal anesthesia without mesh fixation in 1,220 hernia repairs. Hernia. 2009;13(2):115–9.

11. Nathan JD, Pappas TN. Inguinal hernia: an old condition with new solutions. Ann Surg. 2003;238(6 Suppl):S148–57.

12. Bittner R, Schwarz J. Inguinal hernia repair: current surgical techniques. Langenbecks Arch Surg. 2012;397(2):271–82.

13. Lau H, Wong C, Chu K, Patil NG. Endoscopic totally extraperitoneal inguinal hernioplasty under spinal anesthesia. J Laparoendosc Adv Surg Tech A. 2005;15(2):121–4.

14. Fierro G, Sanfilippo M, D'Andrea V, Biancari F, Zema M, Vilardi V. Transabdominal preperitoneal laparoscopic inguinal herniorrhaphy (TPLIH) under regional anaesthesia. Int Surg. 1997;82:205–7.

15. Athanasakis E, Saridaki Z, Kafetzakis A, Chrysos E, Prokopakis G, Vrahasotakis N, et al. Surgical repair of inguinal hernia: tension free technique with prosthetic materials (Gore-Tex Mycro Mesh expanded polytetrafluoroethylene). Am Surg. 2000;66(8):728–31.

16. Monaghan RA, Meban S. Expanded polytetrafluoroethylene patch in hernia repair: a review of clinical experience. Can J Surg. 1991;34(5):502–5.

17. Nienhuijs S, Staal E, Strobbe L, Rosman C, Groenewoud H, Bleichrodt R. Chronic pain after mesh repair of inguinal hernia: a systematic review. Am J Surg. 2007;194(3):394–400.

18. Aasvang E, Kehlet H. Surgical management of chronic pain after inguinal hernia repair. Br J Surg. 2005;92(7):795–801.

19. Bringman S, Wollert S, Osterberg J, Smedberg S, Granlund H, Heikkinen TJ. Three-year results of a randomized clinical trial of lightweight or standard polypropylene mesh in Lichtenstein repair of primary inguinal hernia. Br J Surg. 2006;93(9):1056–9.

20. Markar SR, Karthikesalingam A, Alam F, Tang TY, Walsh SR, Sadat U. Partially or completely absorbable versus nonabsorbable mesh repair for inguinal hernia: a systematic review and meta-analysis. Surg Laparosc Endosc Percutan Tech. 2010;20(4):213–9.

21. Junge K, Rosch R, Klinge U, Saklak M, Klosterhalfen B, Peiper C, et al. Titanium coating of a polypropylene mesh for hernia repair: effect on biocompatibilty. Hernia. 2005;9(2):115–9.

22. Koch A, Bringman S, Myrelid P, Smeds S, Kald A. Randomized clinical trial of groin hernia repair with titanium-coated lightweight mesh compared with standard polypropylene mesh. Br J Surg. 2008;95(10):1226–31.

23. Champault G, Bernard C, Rizk N, Polliand C. Inguinal hernia repair: the choice of prosthesis outweighs that of technique. Hernia. 2007;11(2):125–8.