

**ΜΕΤΑΠΤΥΧΙΑΚΟ ΠΡΟΓΡΑΜΜΑ ΣΠΟΥΔΩΝ:
“ΕΛΑΧΙΣΤΑ ΕΠΕΜΒΑΤΙΚΗ ΧΕΙΡΟΥΡΓΙΚΗ,
ΡΟΜΠΟΤΙΚΗ ΧΕΙΡΟΥΡΓΙΚΗ ΚΑΙ ΤΗΛΕΧΕΙΡΟΥΡΓΙΚΗ”**

**ΕΘΝΙΚΟ ΚΑΙ ΚΑΠΟΔΙΣΤΡΙΑΚΟ ΠΑΝΕΠΙΣΤΗΜΙΟ ΑΘΗΝΩΝ
ΙΑΤΡΙΚΗ ΣΧΟΛΗ**

ΔΙΠΛΩΜΑΤΙΚΗ ΕΡΓΑΣΙΑ

ΘΕΜΑ: “Spleen rupture and minimal invasive splenectomy, a review”

**ΜΕΤΑΠΤΥΧΙΑΚΗ ΦΟΙΤΗΤΡΙΑ:
ΛΙΒΕΡΑΚΟΥ ΕΥΑΓΓΕΛΙΑ
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ΤΗΣ ΣΥΝΕΔΡΙΑΣΗΣ ΤΗΣ ΤΡΙΜΕΛΟΥΣ ΕΞΕΤΑΣΤΙΚΗΣ ΕΠΙΤΡΟΠΗΣ
ΓΙΑ ΤΗΝ ΑΞΙΟΛΟΓΗΣΗ ΤΗΣ ΔΙΠΛΩΜΑΤΙΚΗΣ ΕΡΓΑΣΙΑΣ
Της Μεταπτυχιακής Φοιτήτριας Ευαγγελίας Λιβεράκου

Εξεταστική Επιτροπή

- Ν. Νικητέας, Καθηγητής Χειρουργικής **Επιβλέπων**
- Ι. Γκρινιάτσος, Αναπλ. Καθηγητής Χειρουργικής
- Δ. Δημητρούλης, Αναπλ. Καθηγητής Χειρουργικής

Η Τριμελής Εξεταστική Επιτροπή η οποία ορίστηκε από την ΓΣΕΣ της Ιατρικής Σχολής του Παν. Αθηνών Συνεδρίαση της.....¹⁵20..... για την αξιολόγηση και εξέταση της υποψηφίου κας Ευαγγελίας Λιβεράκου, συνεδρίασε σήμερα ../../..

Η Επιτροπή διαπίστωσε ότι η Διπλωματική Εργασία της Κας Ευαγγελίας Λιβεράκου με τίτλο: “Spleen rupture and minimal invasive splenectomy, a review”, είναι πρωτότυπη, επιστημονικά και τεχνικά άρτια και η βιβλιογραφική πληροφορία ολοκληρωμένη και εμπεριστατωμένη.

Η εξεταστική επιτροπή αφού έλαβε υπ’ όψιν το περιεχόμενο της εργασίας και τη συμβολή της στην επιστήμη, με ψήφους προτείνει την απονομή του Μεταπτυχιακού Διπλώματος Ειδίκευσης (Master's Degree), στον παραπάνω Μεταπτυχιακό Φοιτητή.

Στην ψηφοφορία για την βαθμολογία ο υποψήφιος έλαβε για τον βαθμό «ΑΡΙΣΤΑ» ψήφους, για τον βαθμό «ΛΙΑΝ ΚΑΛΩΣ» ψήφους, και για τον βαθμό «ΚΑΛΩΣ» ψήφους Κατά συνέπεια, απονέμεται ο βαθμός «.....».

Τα Μέλη της Εξεταστικής Επιτροπής

- Ν. Νικητέας, **Επιβλέπων** (Υπογραφή) _____
- Ι. Γκρινιάτσος, (Υπογραφή) _____
- Δ. Δημητρούλης, (Υπογραφή) _____

Table of Contents

	Page
1. Introduction.....	4
2. Presentation of Current Reports / The Splenic Injury.....	6
3. Discussion / Conclusion.....	11
4. Abstract.....	12
5. Περίληψη.....	12
6. References.....	13

1. INTRODUCTION:

(a) Basic Anatomy:

Situated posterolaterally in the left upper quadrant of the abdomen, spleen is a highly vascularized organ surrounded by a fibrous capsule. Predominantly, the spleen is perfused by the splenic artery (branch of the celiac trunk), although there is some complementary vascularization by branches of the left gastric artery. The veins do not accompany the arteries within the splenic parenchyma, up until the level of the hilum where they form the splenic vein, which joins the superior mesenteric vein to form the portal vein of the liver.

(b) Minimally Invasive Splenectomy:

The term *minimally invasive splenectomy* ⁽¹⁵⁾ encompasses a number of surgical procedures that involve the either partial or total dissection of the spleen without opening the abdominal cavity. The breadth of minimal invasive splenectomy procedures now include multiport laparoscopic splenectomy, hand-assisted laparoscopic splenectomy (HALS), natural orifice transluminal endoscopic surgery (NOTES), robot-assisted splenectomy and single-port access splenectomy (SPA).

Minimally invasive splenectomy is widely used for a variety of non emergency conditions (such as lymphoma, thrombocytopenic purpura, myelodysplastic syndrome, splenic abscess etc). Recently, minimally invasive splenectomy used for splenic injury, mainly due to blunt abdominal trauma, is increasingly described.

During the preoperative assessment ⁽¹⁵⁾, in a scheduled splenectomy patient, they should undergo a thorough physical exam, measurement of the size of the spleen using ultrasonography, run tests about coagulopathy and finally explain the procedure in order to obtain informed consent. Immunizing the patient against *Haemophilus influenzae*, pneumococcus and meningococcus remains an important preoperative step as it is for open splenectomy. Finally, heparin injections may help to prevent deep vein thrombosis.

Operative Procedures ⁽¹⁵⁾:

- **Multiport Laparoscopic Splenectomy:**

The patient is positioned in the right lateral decubitus position, with the table flexed. A reverse Trendelenburg position allows greater exposure of the left upper quadrant. Incisions are made for three 5 mm trocars and one 12 mm trocar. Access to the splenic vessels is gained by dividing the gastrosplenic ligament entering the lesser sac. Dividing the gastrosplenic ligament along the greater curvature of the stomach should be done with care due to the short gastric vessels. The splenophrenic and splenorenal ligaments are relatively avascular, thus easier to divide.

- **Hand-Assisted Laparoscopic Splenectomy:**

The patient is positioned similar to the Multiport Laparoscopic Splenectomy. Subxiphoid midline, left or right upper quadrant, Pfannestiel or McBurney incision can be introduced for a hand port. Usually, the location will be determined by size and orientation of the spleen. Hand-Assisted Laparoscopic Splenectomy seems useful for massive splenomegaly patients.

- **Robotic Splenectomy:**

Positioning of the patient remains similar as described above. Ultrasonic dissection of the splenic ligaments is undertaken and hilar vessels are typically controlled using an endovascular stapler. A supraumbilical or subumbilical incision may be used to remove the spleen contained in an extraction sac. At the present time, Robotic Splenectomy does not provide any clear clinical benefit in terms of patient outcome, compared to a common Laparoscopic Splenectomy. There may be a current role for robotic splenectomy as a training procedure to allow surgeons to acquire more experience. There is one study citing the possible usefulness of robotic splenectomy in managing more challenging splenectomies.

- **Single-Port Access Splenectomy:**

Positioning of the patient remains similar as described above. In thin patients with normal sized liver, a transumbilical approach may be used. In a patient with splenomegaly, a 2 cm left sided incision is made at the level of umbilicus in the midclavicular line. Two different techniques have been described: One option is to use multiple trocars, introducing them one at a time, after pneumoperitoneum is achieved using a Veress needle, the second option is to insufflate the abdomen to achieve pneumoperitoneum and introduce a multiport device. Different problems have been described, such as clashing of instruments and lack of space. There is a need of standardization of the Single-Port Access Splenectomy.

- **Natural Orifice Transluminal Endoscopic Surgery:**

At this point, very few Natural Orifice Transluminal Endoscopic Splenectomy cases are described (e.g. Targarona et al.), performing the procedure with a hybrid approach, the laparoscopic NOTES-assisted transvaginally. Endoscopic instrumentations designed for this approach seem important to greatly reduce the duration of surgery and improve the operative technique and logistics. Further analysis is required.

Postoperatively, oral intake is commenced as indicated. Nonsteroidal anti-inflammatory drugs are used for analgesia. Deep vein thrombosis prophylaxis is indicated. Patients in future are advised to use antibiotic prophylaxis at the earliest signs of fever or infection.

2. PRESENTATION OF CURRENT REPORTS / THE SPLENIC INJURY

The spleen remains the most commonly affected organ in blunt injury to the abdomen in all age groups. According to current reports, 20 to 40 percent of patients sustaining splenic injury will need surgical management. Current standard is the open surgical techniques, although laparoscopic techniques have been described.

Our goal is to present case reports and small series of laparoscopic splenectomy for spleen injury.

Until today, open abdominal exploration remains the standard approach for an unstable patient who has sustained a splenic injury. However, the use of laparoscopic technique has been described, especially for selected cases of low-grade injuries and in a haemodynamically stable patient.

The most commonly used grading system of splenic trauma is of the American Association for the Surgery of Trauma (AAST) splenic injury scale, as shown below:

Grade	Injury	Description
1	Hematoma	Subcapsular, nonexpanding, <10% surface area
	Laceration	Capsular tear, nonbleeding, <1 cm parenchymal depth
2	Hematoma	Subcapsular, nonexpanding, 10% - 50% surface area intraparenchymal hematoma <5 cm in diameter
	Laceration	1-3 cm in depth, not involving trabecular vessels
3	Hematoma	Subcapsular, >50% of surface or expanding Intraparenchymal hematoma >5 cm or expanding
	Laceration	>3 cm in depth or involving trabecular vessels
4	Hematoma	Ruptured subcapsular or parenchymal hematoma with active bleeding
	Laceration	Involving segmental or hilar vessels with major devascularisation
5	Laceration	Shattered Spleen
	Vascular	Hilar vascular injury with devascularisation

A. S. Taner et al.⁽⁵⁾ followed later by *S. Sauerland et al.*⁽⁴⁾, underline the importance of using diagnostic laparoscopy in evaluating the abdominal trauma patient. When in need to evaluate the abdominal trauma due to lack or difficulties in radiological or clinical examinations, diagnostic laparoscopy is proven to obviate unnecessary laparotomy in approximately 60% of the cases. It is understood that if within a diagnostic laparoscopy, a splenic trauma is exposed, the ability of the surgeon to perform a laparoscopic splenectomy in an emergency state is crucial thus open surgery is avoided.

The first ever case of laparoscopic splenectomy for ruptured spleen was a hand-assisted laparoscopic surgery described by *C. J. Ren et al.*⁽²⁾ in 2000. The writers noted that poor visibility due to bleeding and vascular control were the main obstacles to laparoscopy, thus using the hand – assisted device could help outcome those difficulties, especially the vascular control, and facilitate the laparoscopic surgery for a splenic trauma that until now open surgery is the standard.

Nicola Basso et al.⁽³⁾ were the first to describe a totally laparoscopic splenectomy in 2003, in a patient suffering from delayed spleen rupture during his hospitalization for bone fractures after a motor vehicle trauma.

It is important to note that the first radiological examinations (U/S) showed just small perisplenic and perihypatic fluid collections. After about 10 days of treatment and surgeries for the patient's fractured bones, progressive tachycardia and peritoneal irritation developed. Computed Tomography was performed showing a ruptured spleen.

Laparoscopic procedure was chosen, noting that a red cell-saving machine was used (*Basso et al.* state in their case report that about 2000 mL of autologous blood was returned to the patient). In their discussion, major factors in choosing the laparoscopic approach for a splenectomy in ruptured spleen, are:

- The use of the red cell-saving machine for intraoperative autotransfusion, which minimizes or even excludes the need for blood transfusion.
- The use of harmonic scalpel, for hemostatic cutting and rapid dissection particularly of the short gastric vessels.
- The use of the endoscopic linear stapler, for fast and safe division of the vessels in the hilum.
- The ability to diagnose, the surgeon must have the experience to exclude bleeding or trauma from other abdominal spaces. Experience in routine elective laparoscopic splenectomy is needed.
- Laparoscopic approach offers the best barrier against contamination.
- Minimal effects of laparoscopy in intestinal peristalsis.
- In conclusion, totally laparoscopic splenectomy was performed in a hemodynamically stable patient, using adequate technical instrumentation, in addition to extensive experience in routine laparoscopic splenectomy.

Georgios D. Ayiomamitis et al.⁽⁶⁾ present a rather interesting case, of laparoscopic splenectomy in a Jehovah's Witness (who refuse blood transfusions) after blunt abdominal trauma. It must be noted that, once again, the red cell saver made the procedure feasible. The presented patient suffered a grade III splenic injury, and, whereas the majority of grade I to III splenic injuries undergo conservative approach, gradual but cumulative blood loss forced the laparoscopic splenectomy to avoid delayed spleen rupture. It is stated that laparoscopic splenectomy, used mainly until now for cold cases (e.g. hematologic disorders), has been associated with a reduction of blood loss, an earlier return of bowel function and a significant postoperative hospital stay when compared with open splenectomy, all important reasons for considering the use of laparoscopic approach in an emergency splenectomy for trauma. In their discussion, they state that contrast enhanced CT is supposed to be performed to every trauma patient and only grade V splenic injury is indicated for splenectomy. However, nonoperative management's failure varies up to 50%, and considering the fact that the patient is a Jehovah's Witness, splenectomy was thought the safest approach, underlining again the importance of red cell saver. Adding, the lateral position of the patient on the operating table is recommended for enhanced access and exposure of the hilar vessels. Experience of the medical team in elective splenectomy is again underlined. Finally, Ayiomamitis et al. conclude that the best candidates for laparoscopic splenectomy in splenic injury are the hemodynamically stable patients that nonoperative management failed.

C. G. S. Huscher, A. Mingoli et al.⁽⁷⁾ present a retrospective review of eleven patients that underwent a laparoscopic splenectomy for splenic injury due to blunt trauma. They state the use of two different approaches, the (1) anterior and the (2) semilateral, both using a reverse Trendelenburg positioning and tilting in a way to free the left upper abdominal quadrant from fluids, so that better operating sight is achieved. Only one major complication due to the procedure was observed, being bleeding from the hilar vessels that forced the need of minilaparotomy. In their discussion, the advantages of the laparoscopic approaches over open surgery as mentioned previously, plus the ability to explore the whole abdomen cavity with a minimal invasive technique suggest a valid alternative to open surgery for splenectomy due to spleen injury. In addition, the use of anterior approach is suggested for patients with major bone fractures or other abdominal lesions, whereas the semilateral approach is suggested for uncomplicated patients.

Andrea Carobbi et al.⁽⁸⁾ present a review of ten laparoscopic splenectomy cases for splenic injury due to blunt trauma. In their discussion the need of proper preoperative evaluation with both clinical and imaging examinations is very important. They state that they preferred to operate patients that were stable and could go with nonoperative treatment although had high bleeding risk. The need of experience in laparoscopic splenectomy is again underlined. A new approach in order to reach hemostasis is introduced, moving directly to the splenic hilum, using mechanic staplers and after infero-posterior mobilization, allowing achieving hemostasis in time comparable to the open surgery.

Sharmila Dissanaike et al.⁽⁹⁾ are the first to perform a totally laparoscopic splenectomy for splenic injury grade V shortly after admission. In their discussion they also underline the importance of surgeon's experience in laparoscopic splenectomy. They add the option of angiographic embolization so that the bleeding is contained if a surgical approach is needed in a next step. Finally, they suggest that hemodynamically stable patients with splenic trauma in need of splenectomy, should undergo a laparoscopic approach if the surgeon is experienced.

Kenneth J. Ransom et al.⁽¹⁰⁾ also indicate a laparoscopic splenectomy for splenic trauma after continued bleeding even though an angiographic artery embolization was performed. They state that even though embolization significantly decreases the need for splenectomy, up to 20% of the patients have been reported to continue bleeding, thus in need of splenectomy. They conclude that in a hemodynamically stable patient, the laparoscopic splenectomy is viable and they add that in a patient with rebleeding risk, an angiographic embolization as a bridge to operative therapy may be beneficial.

Arun Prasad et al.⁽¹¹⁾ also present a case of laparoscopic splenectomy after blunt trauma, underlining that patients hemodynamically stable are the best choice for laparoscopic splenectomy, although surgeon's experience and ability to at any time change the process to open surgery are two major factors need to be considered.

Thapar PM et al.⁽¹²⁾ present a case of laparoscopic splenectomy due to spontaneous rupture. Although nonoperative approach is established, the mortality in the first 30 days is reported as approximately 22%, so a splenectomy with laparoscopic approach is thought as the best choice with the patient being hemodynamically stable. It is underlined again that quick control of the haemorrhage is probably the most important step in the laparoscopic approach. They also conclude that hemodynamically stable patients should be considered laparoscopic approach candidates.

Gregory S. Huang et al.⁽¹³⁾ presents a comparison between patients that underwent open splenectomy against patients that underwent laparoscopic splenectomy, both due to blunt trauma. In their results, the open splenectomy patients had lower level of consciousness and more acidosis compared with the laparoscopic ones. Laparoscopic splenectomy patients had longer operating room time although less blood loss and need of fewer transfusions compared to the open splenectomy patients. They state that most laparoscopic splenectomies were performed after nonoperative management or embolization failed. The main limitations of this study are the small sample size plus the fact that urgent situations with patients presenting hemodynamic instability were all treated via open splenectomy (thus meaning no Grade V splenic injury was assessed with laparoscopic splenectomy).

Hongyu Li et al.⁽¹⁴⁾ present an interesting retrospective analysis of partial laparoscopic splenectomy in splenic injury. In a two year time span 21 patients were chosen to perform laparoscopic partial splenectomy due to splenic injury. Main selection criteria were (1) preoperative CT revealing single pole rupture without spleen pedicle injury, (2) blood pressure > 90/60 mmHg and heart rate < 120 bpm, (3) no sign of multiple organ injury. Main reason of trying to keep splenic parenchyma intact, is the asplenic related life threatening complications such as overwhelming postsplenectomy infections (OPSI), thromboembolic events, arteriosclerosis and pulmonary hypertension. Right semidecubitus position with left side elevated and reverse Trendelenburg tilt was the main placement. Especially for the partial laparoscopic splenectomy, ultrasonic shears (harmonic scalpel), was used to mobilize the resecting part of spleen. Branches of splenic artery and vein which supplied the resecting part, were mobilized and transected. Safe demarcation margin was 1 cm, with ultrasonic shears used to transect the splenic parenchyma 1 cm away from the demarcation line. Finally, it is stated that even though not observed through their patients, postoperative pedicle torsion after laparoscopic partial splenectomy is a possibility, thus preserving the ligaments of the remnant part seems useful.

3. DISCUSSION / CONCLUSION

Minimal invasive splenectomy is currently performed for a vast amount of different spleen pathologies, although open surgery is considered the standard process for splenic injury.

We should consider the benefits from using minimal invasive splenectomies, and discuss of the possibility if not using them for every splenic injury, at least categorize the patients that will benefit most.

At this point, the only minimal invasive techniques described for splenectomy in splenic injury are either Multiport Laparoscopic Splenectomy or Hand-Assisted Laparoscopic Splenectomy.

We should at first consider the benefits of using minimal invasive techniques in general. The smaller incision means less pain for the patient and less bleeding postoperatively through the surgical scar. Also, smaller scars could be considered as an extra benefit.

Blood loss though the surgical process is less than in open surgery.

The hospital stay is significantly shorter, which is not only a benefit for the patient but for the health system itself.

The recovery time is significantly shorter using laparoscopic techniques.

Postoperative infections are significantly less using minimal invasive techniques, as less abdominal cavity is exposed.

Finally, it is considered that the laparoscopic camera helps bring closer to the surgeon's sight parts of the abdomen difficult visible through an open surgical process.

We must consider that in an emergency splenic injury situation, time of act is very important.

The abdominal cavity in a severe splenic injury may be filled up with fluids and blood, making it difficult for the surgeon to highlight the important elements for the splenectomy.

Through the presented reports, the most cases where minimal invasive techniques were used for splenectomy due to splenic injury were mostly of less severity (Grade III or IV), or in cases needing splenectomy later through patient's hospitalization. All of them basically were hemodynamically stable patients.

Also, what was common in every report is the reverse Trendelenburg positioning, probably so that the intrabdominal fluids move to the lower abdomen and the gas used for the laparoscopic procedure stays in the upper abdomen, making the important spleen elements visible for the splenectomy.

Another fact that stands out is the use of red cell-saving machine, that surely helps a lot to minimize the blood loss in the whole procedure, especially in the *Georgios D. Ayiomamitis et al.*⁽⁶⁾, where the splenectomy was made possible without any blood transfuse in a Jehovah's Witness Patient.

Last but not least is the surgeon's experience. This factor is something that cannot be changed in the present time of the surgeon who is to deal with a splenic injury in the emergency room. We all should agree that in the end, the procedure of choice must be the one that the surgeon has the most experience and convenience with.

It is important to state that at least a good amount of experience in laparoscopic splenectomy for non emergency reasons is considered vast for the surgeon to proceed in a laparoscopic splenectomy for emergency trauma and splenic injury reasons.

In conclusion, minimal invasive splenectomy through laparoscopic procedure in the abdominal blunt trauma emergency patient is surely something to consider.

Main factors are less blood loss and shorter hospital stay.

Surely the surgeon's experience is something that cannot be changed for the current surgeons but surely can be optimized for the future surgeons if we manage to educate them properly.

Hemodynamically stable patients with less severe splenic injuries should be the first candidates for laparoscopic splenectomies at this point, at least until a surgeon feels comfortable enough using this method for emergency reasons.

4. ABSTRACT:

The spleen is a highly vascularized organ in the left upper abdominal cavity, which is the most commonly injured organ in any abdominal blunt trauma situation.

Almost 20-40% of any splenic injury will eventually need either partial or total splenectomy. Considering the above, splenectomy in an emergency situation is a rather common surgical process.

At the time being, the open splenectomy is considered the gold standard for an emergency patient, although minimal invasive procedures are being described.

Thinking about the benefits of a minimal invasive technique rather than an open surgical process, our goal is to gather any already presented information about minimal invasive splenectomy in the emergency injured patient and discuss the sustainability and feasibility of performing such type of splenectomy over open surgical processes in the near future.

5. Περίληψη:

Ο σπλην αποτελεί ένα υπεραγγειούμενο συμπαγές όργανο στο άνω αριστερό τεταρτημόριο της κοιλίας, το οποίο είναι και το συνηθέστερα τραυματισμένο ενδοκοιλιακό όργανο σε ασθενείς με αμβλύ τραύμα κοιλίας.

Το 20-40% οποιουδήποτε τραυματισμού του σπληνός τελικά θα χρειαστεί είτε μερική είτε ολική σπληνεκτομή.

Λαμβάνοντας υπόψιν τα ανωτέρω, η σπληνεκτομή σε επείγουσα κατάσταση αποτελεί μια σχετικά συχνή χειρουργική πράξη.

Στην παρούσα περίοδο, η ανοιχτή σπληνεκτομή θεωρείται ο χρυσός κανόνας για τον ασθενή των επειγόντων, ωστόσο ελάχιστα επεμβατικές χειρουργικές τεχνικές έχουν περιγραφεί.

Σκεπτόμενοι τα οφέλη των ελάχιστα επεμβατικών χειρουργικών τεχνικών συγκριτικά με τις ανοιχτές χειρουργικές τεχνικές, σκοπός μας είναι να συλλέξουμε τις μέχρι τώρα περιγραφείσες πληροφορίες οι οποίες αφορούν σε ελάχιστα επεμβατικές χειρουργικές σπληνεκτομές στον τραυματία ασθενή των επειγόντων καθώς και να συζητηθεί η σκοπιμότητα και βιωσιμότητα της χρήσης ελάχιστα επεμβατικών χειρουργικών τεχνικών αντί ανοιχτών τεχνικών σπληνεκτομής σε επείγουσα βάση στο μέλλον.

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