Proposal of ecographic classification for seroma after laparoscopic ventral hernia repair

Enrico Maria Salvatore Piazzese · Salvatore Galipò ·
Giovanni Ivan Mazzeo

Received: 3 June 2014 / Accepted: 30 September 2014 / Published online: 7 November 2014
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Abstract

Introduction Seroma is one of the most common complications after laparoscopic ventral hernia repair (LVHR), even if the incidence brought in literature is varying because definition and criterions of evaluation employed in the different studies are not always the same. This study proposes a classification for seroma after LVHR based on ultrasound findings, useful for an assessment of this complication.

Materials and methods On 93 patients submitted to LVHR an ultrasound of the abdominal wall after 3, 7, 15, 21 and 28 days and subsequently at a distance of 3 and 6 months was performed postoperatively. At each control site, sonomorphology characteristics and size of seroma (if present) were noted.

Results At the end of the study using ultrasound findings obtained, a classification scheme for seroma articulated into three groups based on the parameters detected (site, sonomorphology character and volume) was developed, each of which is subdivided into five different classes to which a precise score is assigned. From the sum of the scores assigned, a value (between 3 and 15) that represents a prognostic index (PI) is obtained. A low PI is typical of small asymptomatic seroma that resolves spontaneously in a short time and without the need for invasive therapies; a high PI is typical of more or less symptomatic voluminous seroma that tends to persist for long periods and which often requires an interventional therapeutic approach.

Conclusions This proposed classification helps to perform a precise nosological assessment of seroma after

LVHR, allowing the surgeon to predict the clinical and temporal evolution of this complication and to plan appropriate therapy from time to time. Furthermore this classification can represent a tool to assess the uniqueness of seroma formation in relation to surgical technique used, to the type of material employed and to the method of mesh fixing.

Keywords Ventral hernia · Laparoscopic repair · Seroma · Ultrasound classification

Sommario

Introduzione Il sieroma è una delle complicanze più comuni dopo la riparazione laparoscopica delle ernie ventrali (RLEV), anche se l'incidenza riportata in letteratura è alquanto variabile perché la definizione e i criteri di valutazione impiegati nei diversi studi non sono sempre gli stessi. Proponiamo una classificazione dei sieromi dopo RLEV basata sui rilievi ecografici, che consenta un inquadramento condivisibile di questa complicanza.

Materiali e Metodi Su 93 pazienti sottoposti a RLEV è stata eseguita un'ecografia della parete addominale dopo 3, 7, 15, 21 e 28 giorni e successivamente a distanza di 3 e 6 mesi dall'intervento. Ad ogni controllo sono state annotate sede, caratteri ecosemiologici e dimensioni del sieroma (se presente).

Risultati Alla fine dello studio grazie a tutti i rilievi ecografici ottenuti è stata elaborato uno schema classificativo dei sieromi basato su 3 parametri (sede, caratteri ecosemiologici e volume), ciascuno dei quali suddiviso in 5 diverse classi a cui viene attribuito un preciso punteggio. Dalla somma dei punteggi assegnati si ottiene un valore (variabile da 3 a 15) che rappresenta un indice prognostico (IP). Un IP basso è tipico dei sieromi asintomatici, di piccole dimensioni e che si risolvono spontaneamente in

E. M. S. Piazzese (✉) · S. Galipò · G. I. Mazzeo
General Surgery Unit, San Camillo Clinic, Clinica San Camillo,
Viale Principe Umberto n.71, 98122 Messina, Italy
e-mail: enricopiazzese@hotmail.com

breve tempo e senza necessità di ricorso a terapie invasive; un IP alto è tipico dei sieromi più o meno sintomatici, voluminosi, che tendono a persistere per lunghi periodi e che spesso richiedono un approccio terapeutico interventistico. **Conclusioni** Mediante questa classificazione proposta si può ottenere un preciso inquadramento nosologico e prognostico dei sieromi RLEV, consentendo al chirurgo di “prevedere” l’evoluzione clinica e temporale di tale complicanza e di pianificare la terapia di volta in volta più opportuna. Inoltre questa classificazione può rappresentare uno strumento per valutare con univocità la formazione dei sieromi in relazione alla tecnica chirurgica adottata, al tipo di materiale protesico impiegato e/o al metodo di fissaggio della mesh.

Introduction

Ventral hernias (VH) of the abdominal wall, divided into primitives (umbilical, epigastric, midline, Spigelian) and secondary (incisional), are a frequent problem in general surgery; some authors report that approximately 60 % of repair are performed for primitive VH, while the remaining 40 % for incisional VH [1, 2].

Over the years, in addition to traditional open repair techniques, characterized by a high recurrence rate (up to 50 %), especially if carried out without use of the prosthesis, progressively laparoscopic treatment was claimed. The improvement of preoperative imaging techniques and anesthetic procedures, the availability of new prosthetic materials and technical aids that simplify the operating phases (especially for mesh fixing) resulted in a significant increase in the number of plastic surgeries performed laparoscopically [1–3].

The gradual diffusion of the laparoscopic approach is justified by the fact that they respected the principles of tension-free repair and by the results obtained are promising, and, as reported in several series of statistical studies, often higher than those of traditional techniques (in particular, less post-operative pain, fewer respiratory complications, rapid mobilization of patient with fewer thromboembolic complications; reduction in the time of hospitalization, the rate of surgical site infection and recurrence; best esthetic result) [3–11].

As any surgical procedure, also laparoscopic ventral hernia repair (LVHR) is not free from potential as serious complication related to the surgical techniques (in particular during the introduction of the first trocar or during adhesiolysis), such as accidental injury of bowel and major vessels; besides these, other complications with early and late onset, considered less serious and very similar to those seen after repair with traditional techniques, such as

postoperative ileus, chronic pain, infection of surgical site, the rejection of the prosthesis and the formation of seroma have been reported.[1–11].

The postoperative seroma (PS) is considered the most common complication after LVHR; consists of a fluid collection, predominantly serous, that develops in the periprosthetic space, caused by physiological inflammatory response of tissues to the prosthetic material and which is favored by the non excision of the peritoneum of the hernia sac (which represents a dead space between the mesh and abdominal wall) [12–18]; the peak of PS formation occurs around the 7th day after the intervention and its reabsorption is nearly complete within 90 days [12].

The incidence of the PS after LVHR is quite variable (0.5–78 %) [18]; in fact, if on the one hand several case-series and review of literature report a clinical incidence not exceeding 6 %, on the other hand some authors point out that this complication is documented by ultrasonography of the abdominal wall in the majority of patients (up to 100 %), but that it is clinically apparent in only a proportion of the same. (8–35 %) [1, 6, 7, 12–18]. The latter data confirms other aspect widely reported in literature, namely, that ultrasound compared to clinical examination is a better tool to diagnose the presence of PS. Furthermore, ultrasound compared to other imaging techniques offers significant advantages as it is easily executable, inexpensive, does not expose the patient to radiation, provides imaging in the real time, allows to recognize the mesh and the fixing means and to diagnose other possible complications associated or related (such as dislocation or infection of the prosthesis, the rejection of the mesh or hernia recurrence) [19–25].

The purpose of this study was to determine the incidence of seroma after LVHR by ultrasonography and, on the basis of ultrasound findings, achieving a classification that allows an assessment of this complication.

Materials and methods

In the study, 93 patients subjected to LVHR, 29 cases for primitive VH (31.2 %) and 64 cases for incisional VH (68.8 %) were included.

From the study, patients with: (1) VH with multiple parietal defect (like “swiss cheese”); (2) hernia recurrence; (3) massive incisional hernia with loss of domicile; (4) strangulated hernia and/or with bowel perforation; (5) abdominal diseases associated to be treated at the same time of hernia defect (gallstone disease, endometriosis or other gynecological pathology, appendicular diseases, etc.); (6) anesthetic contraindications to laparoscopy were excluded.

The surgical technique used is schematically described in Table 1 and represented in Fig. 1. All patients included

Table 1 Descriptive scheme of the laparoscopic surgical technique adopted

Operating phase	Description
Access to the peritoneal cavity	<p>Induction of pneumoperitoneum by Veress needle in left subcostal region</p> <p>Introduction of the laparoscope with optical 30° angle, through an optical trocar 10 mm positioned at the left flank</p> <p>Exploration of the peritoneal cavity</p> <p>Positioning under the vision of the other two 5 mm trocar (one in left hypochondriac region and one in the left iliac region), to obtain an ideal triangulation with respect to the site of hernial defect. The eventual placement of additional trocars, even contralateral, depends on the defect or for its size</p>
Lysis of adhesions and reduction of the hernial contents	<p>Lysis of visceral-parietal adhesions (if present) by cold scissors or monopolar or using an ultrasonic dissector (useful in the case of massive incisional hernia with omental incarceration), so as to allow identification of the margins of the hernial defect</p> <p>Preparation of the deep surface of the abdominal wall for a minimum space of 4–6 cm from the hernial defect, used for positioning the mesh in the best way</p> <p>Complete reduction of the hernial contents into the peritoneal cavity in atraumatic mode, checking the vitality of the viscera and hemostasis</p> <p>Not perform treatment of the hernial sac</p>
Measurement of the hernial defect and introduction of mesh in the peritoneal cavity	<p>Reduction of pneumoperitoneum from 12 to 7–8 mmHg, to obtain a more adequate definition of the size of the parietal defect</p> <p>Measurement of the hernial defect by intracorporeal</p> <p>Considered an overlap of at least 4 cm, using four transparietal spinal needles placed at the cardinal points and a dermatographic pen, mark on the skin reference points for choosing the right size of the mesh</p> <p>Introduction of the prosthesis into the peritoneal cavity through the trocar 10 mm, after having rolled up carefully</p>
Positioning and fixation of the prosthesis	<p>In the case of prosthesis of medium/large size, make four stitches not absorbable monofilament stitches to facilitate the suspension and the correct positioning of the mesh, using a tool “suture passer”</p> <p>Fixation of the prosthesis to the abdominal wall by application of tack titanium or resorbable, in double crown</p>

At the end of the operation, apply an elastic bandage abdominal compression, which should be maintained for the first 3 weeks postoperatively

in the study underwent ultrasound evaluation of the abdominal wall with high-frequency linear probe (3–12 MHz) and if necessary also with convex probe (in 20 cases; equal to 21.5 %).

Ultrasound examination was performed in all cases from the same operator using the same equipment (Philips En-Visor C 1.5 version), with the following time schedule: 3, 7, 15, 21, 28 days after the intervention and subsequently at a distance of 3 and 6 months.

Before ultrasound examination no special preparation was carried out. The patient was placed generally in the supine position and, if necessary in a lateral position or oblique left or right, making him perform deep inspirations.

The abdominal wall was studied by longitudinal and transverse scans, without exerting too much compression with the probe, starting with the most cranial point of the site of previous hernia and moving in the caudal direction and then laterally; evaluation of the surgical site during the Valsalva maneuver and by means of doppler ultrasound was also performed.

At each control site, sonomorphology character and dimension of seroma (if present) were noted. Measuring the volume of the fluid collection (V) using the cuboid formula was performed, which is expressed by the geometrical calculation $V = L \times W \times D$, where L indicates the length (longitudinal extension), W the width (transverse extension) and D the depth (anteroposterior extension).

Results

The clinical and demographic data of the patient included in the study are shown in Table 2, while the intraoperative and postoperative results are summarized in Table 3. Table 4 shows the data related to the clinical and ultrasonographic finding of postoperative seroma.

Using ultrasound findings obtained, a classification scheme for seroma articulated into three groups based on the parameters detected (site, sonomorphology

Fig. 1 Schematic representation of the LVHR. *Panel a* ventral hernia midline cross sectional representation. *Panel b* representation after reduction of the hernial contents into the peritoneal cavity. The hernial sac is not excised. *Panel c* representation of the mesh placet in the intraperitoneal site (device blue color) by a double row of tacks and with an overlap of at least 4–5 cm

Table 2 Clinical and demographic data of the patient included in the study

Mean age	51 years (range 24–81)
Sex (male/female)	36/57
Body mass index	25.9 (range 18.1–35.9)
Hernia incarceration	27/93 (29 %)
Type and site of hernial defect	Primitive VH 29 cases (31.2 %): Umbilical 17 cases Epigastric 11 cases Spigelian 1 case Incisional VH 64 cases (68.8 %): Midline 43 cases Border 21 cases

characteristics and volume) was developed, each of which is subdivided into five different classes to which a precise score is assigned (Table 5; Figs. 2, 3). From the sum of the scores assigned, a value (between 3 and 15) that represents a prognostic index (PI) is obtained.

Table 3 Intraoperative and postoperative data

Pneumoperitoneum induction	Veress 91 cases (97.8 %) open 2 cases (2.2 %)
Number of trocars used	3 in 90 cases (96.8 %) >3 in 3 cases (3.2 %)
Lysis adhesions	81/93 cases (87.1 %)
Mean area of the hernial defect	59.6 cm ² (range 4–419)
Type of prosthesis used	Polyester and porcine collagen in 54 cases (58.1 %) Polyethylene terephthalate and dimethylsiloxane in 19 cases (20.5 %) Polyester and polyurethane in 10 cases (10.7 %) Polypropylene and polyethylene terephthalate in 10 cases (10.7 %)
Fixing means used	Titanium tack in 46 cases (49.5 %) Absorbable tack in poly(glycolide-co-L-lactide) in 42 cases (45.2 %) Absorbable and titanium Tack in 5 cases (5.3 %)
Mean operative time	73 min (range 25–170)
Mean postoperative hospital stay	4.7 days (range 2–12)
Morbidity	Global 19.5 % specific 10.7 %
Mortality	0 %

Discussion

The results of our experience do not differ from those reported in the literature [1, 6, 7, 12–18], both as regards the clinical incidence of PS after LVHR (8.6 % of operated patients) and its sonographic diagnosis (93.5 % of operated patients).

From an analysis of the literature, the discrepancy of the data on the incidence of the PS after LVHR seems to be due both to the fact that this “complication/incident” is often asymptomatic (detectable only with imaging techniques such as ultrasound or computed tomography) or poorly symptomatic for long time. Because the definition and evaluation criteria used in several published studies (clinical or and/or radiological) are not always the same [1, 2, 6, 7, 12–18]; for this reason it would be useful to have a tool that allows a classification shareable for PS.

To date, the literature has reported only one proposal for the classification of seroma after LVHR, published by Morale-Conde in 2012 [18] and divided into the following groups and subgroups:

- Type 0 → No clinical seroma: being Type 0a no seroma after clinical examination and radiological examinations and Type 0b those detected radiologically but not detected clinically.

Table 4 Data related to the clinical and ultrasonographic finding of postoperative seroma

Incidence	Ultrasound evidence in 87/93 cases (93.5 %) also clinic evidence in 8/93 cases (8.6 %)
Sex (male/female)	31/56
Temporal evolution (ultrasound evidence)	1° control (after 3 days) 79/93 cases (84.9 %)
	2° control (after 7 days) 87/93 cases (93.5 %)
	3° control (after 14 days) 52/93 cases (55.9 %)
	4° control (after 21 days) 29/93 cases (31.1 %)
	5° control (after 28 days) 17/93 cases (18.2 %)
	6° control (after 3 months) 7/93 cases (7.5 %)
	7° control (after 6 months) 2/93 cases (2.1 %)
	Persistent seroma after 3 months: 7/87 cases (8.04 %)
	Persistent seroma after 6 months: 2/87 cases (2.29 %) ^a
Other complications associated	Postoperative ileus 3/87 cases (3.44 %)
	Chronic postoperative pain 2/87 cases (2.29 %)
	Recurrence 2/87 cases (2.29 %) ^b

^a In 1 case recourse to non-conservative treatment (1.14 %)^b In 1 case post-traumatic (after road accidents)

- Type I → Clinical seroma lasting less than 1 month.
- Type II → Seroma with excessive duration. Clinical seroma lasting more than 1 month: being Type IIa between 1 and 3 months and Type IIb between 3 and 6 months.
- Type III → Minor seroma-related complications. Symptomatic seromas that may need medical treatment. Minor complications include: Type IIIa: clinical seroma lasting more than 6 months, Type IIIb: esthetic complaints of the patient due to seroma, Type IIIc: important discomfort that does not allow activity to the patient, Type IIId: pain, Type IIIe: with cellulitis;
- Type IV → Seroma that needs to be treated. Major seroma-related complications include the need to puncture the seroma, seroma drained spontaneously, open approach, deep infection, recurrence and mesh rejection.

This classification is primarily based on clinical criteria, namely the recognition of seroma during physical examination, the presence of any associated discomfort (that allow or restrict normal activities) or related complications (pain, superficial or deep infection, recurrence and mes

Table 5 Postoperative seroma ultrasound classification

Parameters	Description	Score
Site		
Level A	Neck of the hernia sac	1
Level B	Body of the hernia sac	1
Level C	Bottom of the hernia sac	1
Level D	Space between the mesh and the abdominal wall	1
Level E	Space between the mesh and intestinal loop	1
Sonomorphology characteristics		
Type I	Simple (anechoic or tenuously hypoechoic)	1
Type II	Corpusculated (anechoic or tenuously hypoechoic, with millimetric hyperechoic echoes in suspension that move with the compression)	2
Type III	Stratified (anechoic or tenuously hypoechoic, with echoes stratified in the bottom part of fluid collection that move to the change of decubitus of the patient)	3
Type IV	Septate (anechoic or tenuously hypoechoic, with few/several hyperechoic septa that do not modify to the change of decubitus of the patient)	4
Type V	Complex (anechoic or tenuously hypoechoic, with deposit more or less irregular hyperechoic solid material that do not move to change of decubitus of the patient)	5
Size		
Exiguous	Volume $\leq 20 \text{ cm}^3$	1
Small	Volume from 21 to $\leq 50 \text{ cm}^3$	2
Medium	Volume from 51 to $\leq 100 \text{ cm}^3$	3
Large	Volume from 101 to $\leq 150 \text{ cm}^3$	4
Extra large	Volume $\geq 151 \text{ cm}^3$	5

rejection), the need for treatment (conservative or invasive) and the time duration of seroma same. According to the author by applying this classification scheme the seroma may be defined as an incident if it is included in the group I and II and instead as a complication if it is included in group III and IV.

If on the one hand, this classification is easy to apply and provides an acceptable definition of seroma as an incident or as complication depending on the group which includes, on the other hand does not consider some possible patient-related variables (for example different threshold of pain that exists between an individual and the other which could include similar situation in a different group) or any interference of the therapies practiced (for example, the different use of analgesic and/or anti-edema drugs between a patient and the other, which can make the real level of pain and/or discomfort) or inherent limitations of the physical examination (for example, in obese patient, for

Fig. 2 Representation of the 5 possible sites for the formation of PS after LVHR

Fig. 3 Representation of the 5 possible type of PS after LVHR

Fig. 4 Sonographic findings of the abdominal wall after LVHR. *Panels a–b* longitudinal and transverse scans along the midline (epigastrium) acquired through linear probe. Evidence of a small collection anechoic (type I) in correspondence of the neck of hernial sac (site A). The mesh is well-positioned (hyperechoic streak indicated by *white arrows*). *Panel c* longitudinal scan along the midline (epigastrium) acquired through linear probe. No evidence of periprosthetic collections. The mesh is well positioned (hyperechoic streak indicated by *white arrows*) and a tack fixation is viewable (hyperechoic spot with weak shadow back indicated by the *yellow*

arrow). *Panel d* longitudinal scan along the midline (hypogastrum) acquired through linear probe. Evidence of a small subcutaneous gas collection (hyperechoic streak with posterior acoustic barrage, indicated by *green arrows*), caused by the presence, in the first days after surgery, a residue of carbon dioxide in the hernial sac. *Panels e–f* transverse scans along the midline (hypogastrum) with evidence of a small collection corpusculated (type II) in correspondence of the neck of hernial sac (site A); comparison between acquisition with linear probe and convex probe

very thick subcutaneous fat, the seromas deep, although voluminous may not be palpated). Also, the inclusion of the patient in one of the five groups does not appear to provide any prognostic indication on the possible evolution of seroma, because some of the characteristics of the fluid collection can not be evaluated with physical examination alone (in particular, the volume, the extension in depth and the influence on the fixing of the mesh) and especially before there is a late complication (for example, the dislocation of the prosthesis, cause of hernial recurrence).

The classification proposed by us, however, was structured using the findings obtained by ultrasound which, as widely reported in the literature, is a superior tool compared to physical examination in the recognition of presence of a postoperative fluid collection (with a sensitivity of 83.3–100 % and a specificity of 98.2–100 %) and in the definition of the dimension, sonomorphology

characteristics and relationships with the mesh and hernial sac [19–25]; the last three findings represent, in particular, the fundamental criteria on which to base our classification.

In our experience, the abdominal wall has been studied in a optimal way with high-frequency ultrasound probes (3–12 MHz) which identify the cutis, superficial fascia, subcutaneous fat, the muscle groups (the external and internal oblique, the transversalis and abdominis rectus), preperitoneal fat and the parietal peritoneum; the latter manifests as a thin, fairly echoic line. In all the cases studied, ultrasound depicted the mesh (which appeared as a hyperechoic, typically wavy, band-like structure with posterior acoustic shadowing), the means of fixing (which appeared as a hyperechoic point-like images with thin posterior acoustic shadowing) and the possible presence of a postoperative collection (noting site, sonomorphology characteristics and volume) (Figs. 4, 5, 6, 7). In some cases

Fig. 5 Example cases of seroma of type I and II. *Panel a* longitudinal scan along the midline (hypogastrium) acquired through linear probe. Evidence of a modest anechoic collection (type I) in correspondence of the hernial sac (site B and C). *Panel b* longitudinal scan along the midline (hypogastrium) acquired through linear probe. Evidence of voluminous anechoic collection (type I) in correspondence of the hernial sac (site A, B and C). *Panel c* longitudinal scan along the midline (epigastrium) acquired through linear probe. Evidence of a modest anechoic collection (type I) in correspondence of the hernial neck and intraperitoneal (site A and E). *Panel d* longitudinal scan along the midline (epigastrium) acquired through linear probe. Evidence of a modest anechoic collection (type I) in the space between mesh and parietal peritoneum (site D). *Panel e* longitudinal scan along the midline (epigastrium) acquired through linear probe. Evidence of a modest corpusculated collection (type II) in correspondence of the hernial sac (site B and C). *Panel f* longitudinal scan along the midline (hypogastrium) acquired through linear probe. Evidence of a voluminous corpusculated collection (type II) intraperitoneal (site E)

(21.5 %), the study was completed with a convex probe (3.5 MHz) (Fig. 4), particularly useful in patients with abundant subcutaneous fat; in fact, these patients, compared to lean subjects, exhibit an inevitable reduction in the resolution of superficial images.

Moreover, the low frequency convex transducer allows detection of possible other intra-abdominal collections. In

our experience, measuring the volume of the PS was performed using the cuboid formula, as suggested by Peiper [20]; the volumetric parameter is important because it seems to be directly related to the persistence of the fluid collection. Indeed, we found that 7 cases of PS with persistence longer than 3 months (7.5 %) and 2 cases with persistence for more than 6 months (2.1 %) were those

Fig. 6 Example cases of the seroma of type III and IV. *Panel a* longitudinal scan along the midline (hypogastrium) acquired through linear probe. Evidence of modest stratified collection (type III) in correspondence of hernial sac (site B and C). *Panel b* transverse scan along the midline (hypogastrium) acquired through linear probe. Evidence of a modest stratified collection (type III) in correspondence of the hernial neck and sac (site A and B). *Panel c* transverse scan on the right upper abdominal quadrant acquired through convex probe. Evidence of a voluminous stratified collection (type III) in correspondence of the hernial sac (site B and C). *Panel d* longitudinal scan along the midline (hypogastrium) acquired through linear probe. Evidence of a voluminous septate collection (type IV) in correspondence of the hernial neck and sac (site A, B and C). *Panel e* transverse scan along the midline (epigastrium) acquired through linear probe. Evidence of a voluminous septate collection (type IV) in correspondence of the hernial sac (site B and C). *Panel f* transverse scan along the midline (hypogastrium) acquired through linear probe. Evidence of a modest septate collection (type IV) in correspondence of the hernial sac (site B and C)

with calculated volume, respectively, exceeding 100 cm^3 and 150 cm^3 ; this is probably because a larger collection is reabsorbed unlikely in the short term, even early treatment using anti-edema drugs and/or applying in a prolonged abdominal elastic compression.

Also the sonomorphology characteristics of the collection appear to be related to the persistence of PS. In our series, we observed that 7 cases of PS persisting longer than 3 months were classified more or less early in the

Type V (5 patients) and IV (2 patients, both with persistence of collection more than 6 months); this is probably because the septa or hyperechoic deposits (specific type IV and V, respectively) are the final results of the inflammatory phenomena (in particular with accumulation of fibrin) and local organizational processes (in presence of blood clots or fat necrosis), and for these reasons it is difficult to resorb and in longer periods, especially when compared with the simple PS (Type I), which instead resolve

Fig. 7 Example cases of the seroma of type V *Panel a* longitudinal scan along the midline (epigastrium) acquired through linear probe. Evidence of a modest complex collection (type V) in correspondence of the hernial sac (site B and C). *Panel b* transverse scan along the midline (hypogastrium) acquired through linear probe. Evidence of modest complex collection (type V) in correspondence of the hernial sac (site B and C). *Panel c* transverse scan along the midline

(hypogastrium) acquired through linear probe. Evidence of a voluminous complex collection (type V) in correspondence of the hernial sac and intraperitoneal (site A, B, C and E). *Panel d* longitudinal scan along the midline (hypogastrium) acquired through linear probe. Evidence of a voluminous complex collection (type V) in correspondence of the hernial neck and sac (site A, B and C)

spontaneously in a few days or weeks. About the PS of type II and III, we have observed that these often temporally precede the formation of those of type IV and V, probably because the echoes in suspension or stratified in the lower portion of the collection, in case of prevalence of the phenomena of local organization (compared to those of absorption), can form more or less early the septa or solid deposits hyperechoic; if, instead, prevail the reabsorption process, collection corpusculated or stratified tend to behave like those of type I, resolving in a few weeks.

On the basis of these hypothesis of evolution of seroma, the collection of type I can be defined as “initial seroma”, those of the type II and III as “transition seroma” and those of type IV and V as “inveterate seroma” (Fig. 8). About the site of PS, we noticed that the collections that persist for more time are those that are formed mainly at the level of the hernial sac (especially those of the site B and C) compared with those deep (site D and E) which probably benefit from a more efficient and rapid absorption by the peritoneum.

The classification proposed by us besides, to have a descriptive utility could be an important prognostic tool for

the surgeon; in fact, the value of PI (obtained from the sum of the score after assignment in the subgroups, ranging from 3 to 15) seems to provide guidance on the possible evolution of the seroma. In our experience, we have found that a low value of PI (less than 6) is more frequent in small and asymptomatic seromas that are resolved in a short time and without the need to resort to invasive therapies; instead, in the case of high values of PI (if superior to 10) is often in the presence of PS more or less symptomatic and voluminous that tend to persist for long periods and that sometimes complicated and/or require an invasive treatment. On the basis of these considerations, we may distinguish three different prognostic classes: collections in which, after some ultrasound follow-up, stood a volume of PI between 3 and 6 can be defined as “PS with favorable prognosis” (benign evolution with easy resolution), those with a value of PI between 7 and 10 as a “PS with intermediate prognosis” (uncertain evolution with possible resolution or chronic) and those with a value of PI between 11 and 15 as a “PS with complicated prognosis” (complex evolution with a tendency to chronicity) (Table 6). Starting from this prognostic classification in the future could

Fig. 8 Hypothesis of postoperative seroma evolution We hypothesized that the seroma of type II e III (defined as transition seroma) temporally precede the formation of those of type IV and V (defined as inveterate seroma), probably because the echoes in suspension or stratified in the lower portions of the collection, in case of prevalence of the local processes of organization (compared to those of absorption), may be formed more or less early the septa or solid deposits hyperechoic; instead if prevail the processes of absorption, the seroma corpusculated and stratified tend to behave like those of the type I (defined as initial seroma), resolving in a few weeks

standardize specific protocols for the prevention and treatment of PS.

In spite of the promising applications of this innovative classification, probably susceptible to future change, we believe that further studies on the series numerically significant to test its validity are needed.

Conclusions

Despite the promising results with the use of modern laparoscopic technique in ventral hernia repair, a number of

Table 6 Prognostic classes of postoperative seroma

Value PI	Prognosis	Evolution of seroma
Range 3–6	Favorable	Benign evolution with easy resolution
Range 7–10	Intermediate	Uncertain evolution with possible resolution or chronic
Range 11–15	Complicated	Complex evolution with a tendency to chronicity

specific postoperative complications are reported in the literature; the PS is the most frequent and difficult to recognize. The postoperative assessment of patients who have undergone LVHR is usually based on physical examination, but may be difficult and limited (especially in the obese) and therefore gives rise to misinterpretations about the real presence of PS.

Ultrasound is a useful complement to physical examination allowing to better investigate the surgical site, to directly visualize the implanted prosthesis and recognize and characterize the postoperative collection.

In our experience, using the ultrasound findings obtained in patients undergoing LVHR, we developed a classification of P that facilitates clinical and prognostic assessment of this complication; in fact may represent a useful tool for the surgeon to predict the clinical and temporal evolution of PS and then to plan the treatment most appropriate (it is to envisage the standardization of therapeutic protocols based on the value of PI). Moreover, this proposed classification, probably susceptible to future changes, may represent for the various authors the most appropriate method for evaluating objectively the formation of PS in relation to surgical technique adopted and in particularly in relation to the treatment of the hernial sac (cauterization of peritoneum, excision, obliteration, etc.), the type of prosthetic material (biological, synthetic or mixed), the characteristics of the mesh (macroporous, with holes) and of the fixing means (titanium or absorbable tack, in single or double crown, biological glues, etc.)

Conflict of interest The authors (Enrico Maria Salvatore Piazzese, Salvatore Galipò, Giovanni Ivan Mazzeo) have no conflict of interest.

Informed consent All procedures followed were in accordance with the ethical standards of the responsible committee on human experimentation (institutional and national) and with the Helsinki Declaration of 1975, as revised in 2000 (5). All patients provided written informed consent to enrolment in the study and to the inclusion in this article of information that could potentially lead to their identification.

Human and animal studies The study conducted in accordance with all institutional and national guidelines for the care and use of laboratory animals.

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