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ORIGINAL ARTICLE

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# The ratio between anterior abdominal wall surface/wall defect surface: a new parameter to classify abdominal incisional hernias

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**Abstract** Current classifications of incisional hernias are often not suitable. The aim of our study was to demonstrate that it is important to consider not only the wall defect surface (WDS) but also the total surface of the anterior abdominal wall (SAW) and the ratio between SAW/WDS). Twenty-three patients affected by >10 cm size incisional hernias were examined for anthropometric analyses. The SAW, the WDS and the ratio SAW/WDS were calculated. All of the 23 patients were operated on 13 patients were treated with the Rives technique using a polypropylene mesh while the remaning ten patients had an intraperitoneal Parietex Composite mesh (PC). The two groups were compared for post-operative pain (with VAS) and intra-abdominal pressure (IAP) 48 h after the operation: bladder pressure, length of the procedure, average hospital stay and return to work were calculated. In the Rives group, WDS being equal, the higher IAP values were, the lower was the ratio SAW/WDS; furthermore, SAW/WDS ratio being equal, IAP values were low in cases where intraperitoneal mesh was used. Post-operative pain, measured with VAS, was critical when there was a low SAW/WDS ratio and a high IAP. In our experience, it is possible to predict a strong abdominal wall tension if the SAW/WDA ratio is below 15 mmHg. In these cases it is advisable to use a technique requiring the use of an intraperitoneal mesh. Our experience with PC was so positive that it is used in our department for all cases where an intraperitoneal mesh is required. At present, our proposal is that the SAW/WDS ratio is to be considered as a new parameter in current classifications of incisional hernias.

**Keywords** Classification of incisional hernias · Ratio between anterior abdominal area/wall defect area · Parietex composite

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## Introduction

Despite the progress of laparoscopy, abdominal wall incisional hernias are still a frequent pathology: because of the progress of anesthesiology and support therapies, an increasing number of elderly, obese patients and those affected by debilitating systemic pathologies undergo complex open surgical procedures.

The most frequent cause of primary incisional hernia is infection of the wound, while a recurrent incisional hernia is frequently caused by excessive wall tension.

The most popular classifications of incisional hernias consider the width of the parietal defect to be one of the most important parameters; However, neither the width of the parietal defect alone nor its area wall defect surface (WDS) is sufficient to classify an incisional hernia correctly.

Other authors' experiences have already demonstrated that, WDS being equal, it is easier to treat an incisional hernia which is larger in height than in width.

Our experience shows that it is extremely important to consider the anterior abdominal wall surface (SAW) also and, therefore, the patient's constitution.

If the SAW/WDS ratio is low, strong wall tensions may be generated after the procedure. The aim of our study is to demonstrate that this ratio is useful in predicting a strong wall tension and, therefore, it must be included as a new parameter for classifying incisional hernias.

## Materials and methods

Since June 2002, we have carried out anthropometric tests on 23 patients affected by >10 cm size incisional hernias (W3–W4 according to Chevrel and Rath [1] or larger according to modified Chevrel classification [2].

In all 23 patients SAW and WDS were calculated. The anterior abdominal wall shape is an irregular hexagon; when calculating the area we must take into

consideration that the surface wall is irregular and shows an anterior convex curve, which varies according to the patient's build: we believe that it could be calculated by multiplying the length of the bisiliac by the xyphopubic lines. The WDS was calculated as follows:

1. The shape of the wall defect was traced onto a transparency,
2. The transparency was scanned,
3. The area of any wall defect, even irregular ones, is rapidly calculated by the AutoCad Software (Autodesk Development Inc.),
4. Then, the ratio between SAW/WDS was calculated in all 23 patients. All of them underwent surgical procedure: the 13 patients were treated with a polypropylene mesh (Parietene) in the retromuscular site after closure of the peritoneum and the posterior rectus sheath; the mesh was sutured with transparietal stitches of Prolene OO according to the Rives technique.

The remaining ten were treated with an intraperitoneal PC mesh, according to their SAW/WDS ratio values.

The mesh was put in contact with the bowel (with epiploon in between if possible) and the polyester side was sutured to the wall by U stitches of Prolene OO with an overlap of at least 6 cm both laterally and longitudinally from the parietal defect.

All patients (seven males/16 females) had an average age of 54 years (range: 36–78). Incisional hernias were classified according to Chevrel: 11 were xiphopubic (M4), four supraumbilical (M1), four subumbilical (M3), three umbilical (M2) and one subcostal (L1): 15 had a defect size between 10 and 15 cm (W3) and eight were $>15$ cm (W4). The incisional hernia was primary in 12 patients (R0), recurrent in seven cases (R1) and multirecurrent in four of them (R2 or R3) (Table 1).

Post-operative pain was measured with VAS at 12, 24, 48 and 72 days after the procedure. In all 23 patients the intra-abdominal pressure (IAP) was detected at 48 h after the surgical intervention once canalization had started.

The IAP was calculated by measuring the pressure of the bladder (BP) filled by 100 ml of physiologic solution and connecting the vesical catheter to a pressure transducer.

Length of the surgical procedure, average hospital stay and return to work were also calculated.

**Table 1** Classification of the 23 ventral hernias of our study (Chevrel)

| Site | Width | Recurrence |
|---|---|---|
| M1:4 | W3:15 | R0:12 |
| M2:3 | W4:8 | R1:7 |
| M3:4 | | R2:3 |
| M4:11 | | R3:1 |
| L1:1 | | |

A fourty-eight hours after the operation, we correlated the ASA score with the IAP of the two groups.

## Results

In Table 2, all the patients' anthropometric data are reported: SAW, WDS, SAW/WDS, kind of surgical procedure, mean IAP and mean body mass index (BMI) of both groups.

In the Rives group, WDS being equal, the higher IAP values were, the lower was the ratio SAW/WDS; furthermore, SAW/WDS ratio being equal, IAP values were low where intraperitoneal mesh was used (Table 2). When we analysed the variances between the two groups, the differences were statistically significant ($p < 0.01$ and test of Fisher = 34.5).

The ten patients treated with an intraperitoneal mesh were patients in whom the SDA/SWD ratio was $<15$ and the Rives technique would have caused excessive wall tension.

Post-operative pain was measured with VAS at 12, 24, 48 and 72 h after the operation and clearly demonstrated how it is strictly correlated to IAP and, therefore, to post-operative wall tension: the higher the IAP, the stronger was the post-operative pain (Figs. 1 and 2).

Patients with an intraperitoneal mesh had less post-operative pain than those operated with the Rives' tecnique (Figs. 3 and 4).

Average operating time was 90 min (range 50–110) in the intraperitoneal group (ten patients) and 120 min (range 100–180) in the remaining 13 patients.

Average hospital stay was 7 days (range 5–14) and return to normal working activity was after 13 days (range 10–25) for the intraperitoneal group and 10 days (range 8–23) and 20 days (range 17–32), respectively, in the Rives' group (Fig. 5).

The average follow-up of our study was 12 months (range 6–20 months). All patients were included.

The post-operative complications were minor in both groups of patients. No post-implant mortality occured. The mesh never had to be removed. Only a partial recurrence in a multirecurrent large incisional hernia was found 11 months after the operation in the Rives' group of patients. No occlusion, bowel sub-occlusion or fistula occurred.

A six months after the operation, none of the patients of the intraperitoneal group showed chronic pain, whereas the three patients in the Rives group had still pain and/or discomfort and the sensation of having foreign body inside them (Table 3).

## Discussion

Even large hospitals rarely ever reach a high number of case histories in this pathology; therefore, it is extremely difficult to compare results.

**Table 2** Patients' anthropometric data

| Patient n | Technique | SAW ($cm^2$) | WDS ($cm^2$) | SAW/WDS | IAP (mmHg) | mean IAP (mmHg) | Mean BMI |
|---|---|---|---|---|---|---|---|
| 1 | Rives | 1830 | 120 | 15.25 | 11.1 | 9.38 | 31 |
| 2 | Rives | 1640 | 95 | 17.26 | 8.8 | | |
| 3 | Rives | 1750 | 105 | 16.57 | 8.4 | | |
| 4 | Rives | 1850 | 100 | 18.5 | 7.2 | | |
| 5 | Rives | 1750 | 110 | 15.91 | 10.5 | | |
| 6 | Rives | 1560 | 95 | 16.42 | 9.0 | | |
| 7 | Rives | 1950 | 120 | 16.25 | 9.4 | | |
| 8 | Rives | 2100 | 75 | 28 | 6.5 | | |
| 9 | Rives | 1560 | 100 | 15.6 | 10.8 | | |
| 10 | Rives | 1380 | 80 | 17.25 | 8.5 | | |
| 11 | Rives | 1450 | 95 | 15.26 | 11.2 | | |
| 12 | Rives | 1510 | 84 | 17.98 | 9.8 | | |
| 13 | Rives | 1640 | 105 | 15.62 | 10.8 | | |
| 14 | Intraperitoneal mesh | 1110 | 80 | 13.88 | 6.5 | 6.22 | 33 |
| 15 | Intraperitoneal mesh | 1100 | 88 | 12.5 | 8.0 | | |
| 16 | Intraperitoneal mesh | 1350 | 115 | 11.74 | 7.0 | | |
| 17 | Intraperitoneal mesh | 1350 | 95 | 14.21 | 5.8 | | |
| 18 | Intraperitoneal mesh | 1700 | 125 | 13.6 | 6.0 | | |
| 19 | Intraperitoneal mesh | 1550 | 130 | 11.92 | 7.0 | | |
| 20 | Intraperitoneal mesh | 1850 | 125 | 14.8 | 5.0 | | |
| 21 | Intraperitoneal mesh | 2050 | 180 | 11.39 | 5.5 | | |
| 22 | Intraperitoneal mesh | 2200 | 160 | 13.75 | 6.0 | | |
| 23 | Intraperitoneal mesh | 1250 | 85 | 14.71 | 5.4 | | |

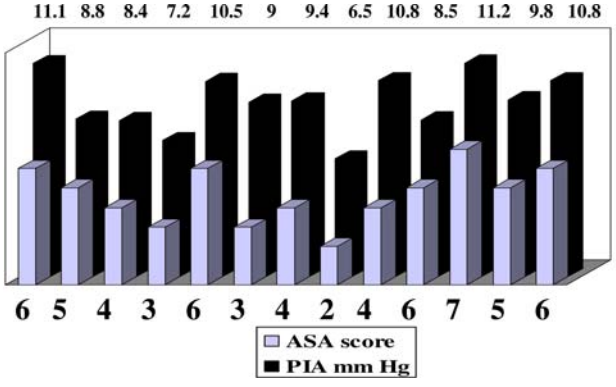


**Fig. 1** Rives technique: comparison between ASA score/IAP at 48 h from operation

Often, the different case histories do not match perfectly as the most frequently used classifications are inadequate and surgical results cannot be compared.

Like in inguinal hernias, there are various types of incisional hernias and these can be classified according to different parameters.

Primary incisional hernias differ from recurrent and multi-recurrent hernias (sometimes with loss of tissue) and these still represent a significant challenge to surgeons.

Other parameters are represented by the hernia site, its size and the number of openings in the abdominal wall.

Scientific literature reports several factors to be of primary importance in incisional hernias formation: sepsis and infection of the wound [3–7], obesity [3, 8], which is present in 45% of primary incisional hernias and in 61% of recurrent defects [1] and is indicated as one of the most important risk factors for recurrencies [9], systemic deseases (chronic hepato pathies, cancer, diabetes, chronic bronchopathies, etc.) [10, 11], prolonged therapy with steroids [11, 12], radiotherapy [11].

The number of previous recurrencies is indicated as statistically unimportant by some authors [1] while, in our opinion, which is in agreement with other authors [13, 14], this represents a further risk factor.

Even a strong wall tension that normally follows the repair of a wall defect may be the cause of a recurrent hernia [12, 15] and the use of a mesh does not always prevent such a risk.

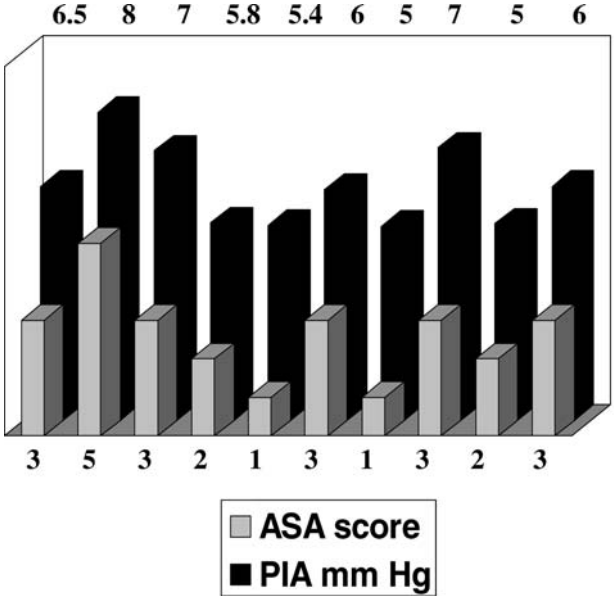


**Fig. 2** Intraperitoneal mesh: comparison between ASA score/IAP at 48 h from operation

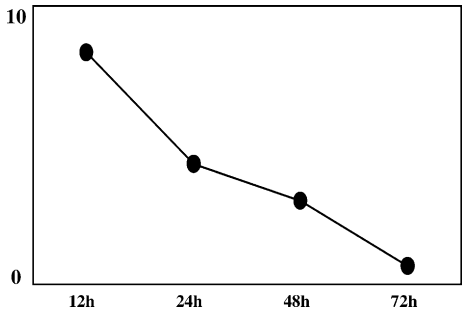


**Fig. 3** Evaluation of post-op. pain by the visual analogue scale (*VAS*) at 12, 24, 48 and 72 h after the operation in the ten patients operated with an intraperitoneal PC

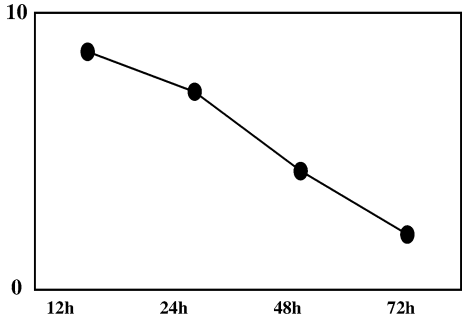


**Fig. 4** Evaluation of post-operative pain by the visual analogue scale (*VAS*) at 12, 24, 48 and 72 h after the operation in the 13 patients operated with the Rives' technique

The Rives' technique [16, 17] is the most widely used technique as it is considered the gold standard in the treatment of incisional hernias. Actually, this technique, though erroneously considered to be ''tension-free'', creates inevitable wall tensions when the defect is really voluminous.

Excessive wall tension can be caused when the mobilization of the abdomen rectus muscles is not correctly performed or, in other cases, if the surgeon insists in using the Rives' technique.

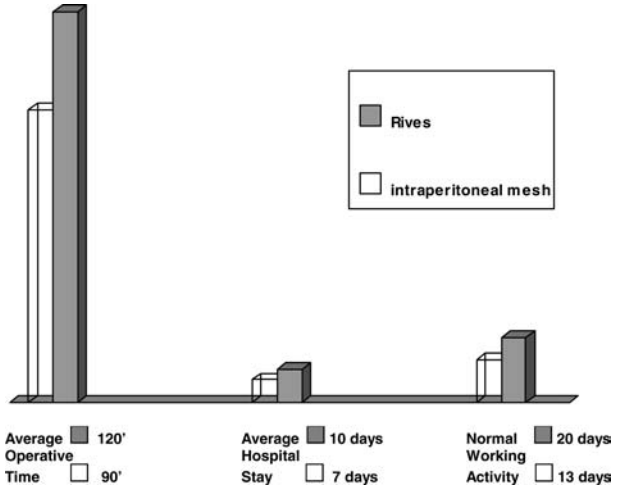


**Fig. 5**

**Table 3** Morbidity 6 months after the operation: comparison between the two groups of patients

| | Intraperitoneal mesh | Rives |
|---|---|---|
| Respiratory insufficiency | – | 1 |
| Intestinal infarction | – | 1 |
| Seromas | – | 2 |
| Hematomas | 1 | 1 |
| Wound suppurations | 1 | 1 |
| Cutaneous necrosis | – | – |
| Peritoneal sepsys | – | – |
| Fistulae | – | – |
| Bowel occlusions | – | – |
| Foreign body sensation | – | 3 |
| Chronic postoperative pain | – | 2 |
| Recurrences | – | 1 |

Excessive wall tension can be avoided if not only the WDS but also, most importantly, the SAW/WDS ratio is considered, as demonstrated.

Some anthropometric evaluations generated very important observations [18]. If a thin patient with a 35 cm bisiliac and a 30 cm xiphopubic lines is compared to a fat patient with a 55 cm biliac and a 50 cm xiphopubic lines, the total area of the anterior abdominal wall, in the second case, is almost three times larger (1 and 2.750 $m^2$, respectively). Consequently a 10 cm large incisional hernia, classified by Chevrel as a medium size [2], represents a 7.48% loss of tissue in the first case and 2.85% in the second case, while a 15 cm large incisional hernia represents 16.82 and 6.42% of loss of tissue, respectively. When the defect has a 10 cm diameter (78.5 $cm^2$), the ratio will be 13.38 and 35.03, respectively. When the defect has a 15 cm diameter (176.6 $cm^2$) the ratio will be 5.94 and 15.57, respectively (Figs. 6 and 7).

From our experience, we can assess that when the SAW/WDS ratio is $<15$, the Rives' technique may increase IAP and therefore wall tension; in these cases, the solution can be the intraperitoneal positioning of the mesh.

We have used PC as an intraperitoneal mesh for 4 years now. The PC is a tridimensional polyester mesh with a reabsorbable, non-stick, collagen-polyethyleneglycol and glycerol membrane which prevents adhesions (Sofradim—France).

In our experience, the indications for use of this mesh in open surgery are:

- Big ventral hernias,
- Border ventral hernias,
- Multirecurrent ventral hernias,
- Ventral hernias with associated pathologies.

From our experience, we assess that the use of an intraperitoneal mesh must be considered when the SAW/WDS ratio is lower than 15 to prevent early postoperative complications, due to the strong wall tension, and to minimize the risk of recurrencies.

Our study also included the evaluation of IAP in all 23 patients. It is widely known that the easiest and

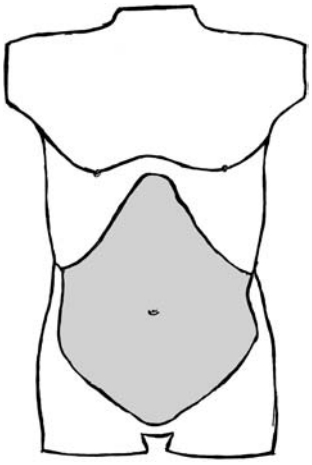

Fig. 6

reliable technique to detect IAP is bladder pressure (BP) [19–25]. The BP is strictly correlated with the IAP and is directly measured in the peritoneal cavity by filling the bladder with 100 ml physiologic solution and connecting the vesical catheter to a pressure transducer or to a water manometer.

The IAP is not influenced only by WDS, as we have seen that WDS and surgical technique being equal, IAP values differ significantly according to the constitution of the patients: the higher IAP values, the thinner the patient.

The link between IAP and the SAW/WDS ratio was indisputably evident; surgical technique being equal, the lower the SAW/WDS ratio, the higher was the IAP.

It is also important to notice that, in the intraperitoneal group, SAW/WDS ratio being equal, IAP values were lower than in the Rives' group as well as postoperative pain.

When a large incisional hernia is surgically treated, IAP may increase rapidly thus preventing the human body from finding the right physiopathologic adaptations (unlike those cases where the IAP increasing trend is slow and chronic like pregnancy, ascites, obesity and in case of voluminous abdominal mass). Furthermore, this could lead to ischemia and to a reduction in tissue trophism, thus slowing down the healing processes and causing possible infections [26].

From a physiopathologic point of view, the IAP increase may affect the circulatory system by compressing the abdominal vessels and generating, in case of high pressure values, a reduction of the brain, heart and renal arteriolic flows and the splenic perfusion.

The intestinal infarction occurred to a patient belonging to the Rives group could be the consequence of an abnormal increase of IAP after the operation.

In addition, the increase of IAP strongly affects the respiratory function. In patients with important ventral hernias, which affect the correct movement of the abdominal wall, this kind of operation must be avoided because of the inevitable consequences it would have on their breathing. Actually, surgical treatments which cause the IAP to increase may endanger patients. In these cases, the respiratory insufficiency is caused by the sudden increase of IAP, which may cause the elevation and the lower mobility of the diaphragm. According to Goni Moreno, in patients with big ventral hernias and a low rate AWS/WDS, the induction of a progressive preoperative pneumoperitoneum can be insufficient. In our experience, in these cases it is better to choose the intraperitoneal technique, which generates a lower increase of IAP than the Rives technique.

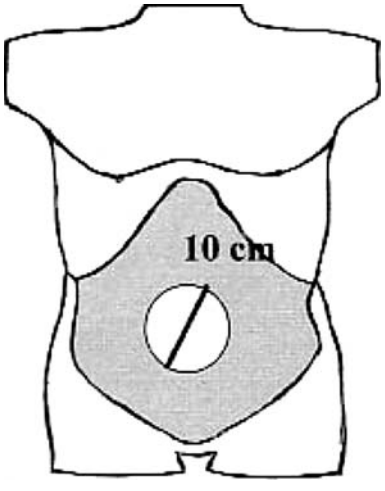


Fig. 7

## Conclusions

In our experience, we recommend adding a new parameter to Chevrel classification: the SAW/WDS ratio; the lower this ratio, the higher will be the risk of high wall tensions. Therefore, also considering the reliability of this new composite mesh, we can assess that in patients in whom the SAW/WDS ratio is lower than 15, an intraperitoneal mesh must be used.

The method we used to calculate AWS, WDS and their relation can be easily followed by anyone with the right equipment, which includes a rule, a transparency, a PC scanner, the AutoCad software and, in order to calculate IAP, a pressure transducer connected to a bladder catheter.

Our experience with PC, as well as other Authors [27–30], is so positive that this mesh is now our first choice when an intraperitoneal positioning is required.

## References

1. Chevrel JP, Rath AM (2000) Classification of incisional hernias of the abdominal wall. Hernia 4:7–11
2. Korenkov M, Paul A, Sauerland S, Neugebauer E, Arndt M, Chevrel JP, Corcione F, Fingerhut A, Flament JB, Kux M, Matzinger A, Myrvold HE, Rath AM, Simmermacher RKJ (2001) Classification and surgical treatment of incisional hernia. Results of an experts' meeting. Langenbecks Arch Surg 386:65–73

3. Bucknall TE (1983) Factors influencing wound complications: a clinical and experimental syudy. Ann R Coll Surg Engl 65:71–78
4. Cameron AE, Parker ES, Gray RC, Wyatt AP (1987) A randomised comparison of polydioxanone (PDS) and polypropylene (Prolene) for abdominal wound closure. Ann R Coll Surg Engl 69:113–115
5. Gys T, Hubens A (1989) A prospective comparative clinical study between monofilament absorbable and non-absorbable sutures for abdominal wall closure. Acta Chir Belg 89:265–270
6. Israelsson LA, Jonsson T (1993) Suture length to wound length ratio and healing of midline laparotomy incisions. Br J Surg 80:1284–1286
7. Smith M, Enquist IF (1967) A quantitative study of impaired healing resulting from infection. Surg Gynecol Obstet 125:965–973
8. Regnard JF, Hay JM, Rea S, Fingerhut A, Flamant Y, Maillard JN (1988) Ventral incisional hernias: incidence, date of recurrence, localization and risk factors. Ital J Surg Sci 18(3):259–265
9. Sauerland S, Korenkov M, Kleinen T, Arndt M, Paul A (2001) Obesity is a risk factor for recurrence after incisional hernia repair. Eur J Surg 167(11):855–859
10. Baggish MS, Lee WK (1975) Abdominal wall disruption. Obstet Gynecol 46:530–534
11. Makishima T (1989) Experimental study of the wound healing in liver cirrhosis. Nippon Geka Gakkai Zasshi 90:1706–1712
12. Ellis H (1976) Wound healing. Ann R Coll Surg Engl 59:382–387
13. Klein P, Konzen G, Schmidt O, Hohenberger W (2004) Reconstruction of scar hernias-intraoperative tensiometry for objective determination of procedure of choice. Chirurg 67(10):1020–1027
14. Reingruber B, Kastl S, Stremmel C, Klein PD (2001) Incisional hernia repair: tensiometry for the selection of the appropriate procedure. Eur J Surg 167(12):903–908
15. Rios A, Rodriguez JM, Munitiz V, Alcaraz P, Perez D, Parrilla P (2001) Factors that affect recurrence after incisional herniorrhaphy with prosthetic material. Eur J Surg 167(12):903–908
16. Rives J, Lerdennois B, Pire JC (1974) Physiopathologie des éventration. 75ème Congrès Français de Chirurgie. Actualites Chirurgicales Paris: Masson
17. Rives J, Pire JC, Flament JB, Palot JP, Body C (1985) Les traitment des grandes éventrations. Chirurgie 111:215–225
18. Ammaturo C, Bassi UA, Rossi R, Santoro M, Iavazzo E, Di Carlo F, Bassi G (2003) Novità nella chirurgia dei grandi laparoceli. Le indicazioni al trattamento ''open'' dei laparoceli con protesi composite. Arch Atti Sic Ed Pozzi 1:63–70
19. Schachtrupp A, Hoer J, Tons C, Klinge U, Record U, (2002) Intra-abdominal pressure: a reliable criterion for laparostomy closure? Hernia 6(3):102–107
20. Tons C, Schachtrupp A, Rau M, Mumme T, Schumpelick V (1998) Abdominal compartment syndrome: prevention and treatment. J Trauma 44(6):1016–1021
21. Gudmundsson FF, Viste A, Gislason H, Svanes K (1995) Comparison of different methods for measuring intra-abdominal pressure. 39(69):1071–1075
22. Kron IL, Harman PK, Nolan SP (1984) The measurement of intrabdominal pressure as a criterion for abdominal reexploration. Ann Surg 199:28–30
23. Lacey SR, Bruce J, Brooks SP (1987) The relative merits of various methods of indirect measurement of intrabdominal pressure as a guide to closure of abdominal wall defects. J Pediatr Surg 22:1207–1211
24. Iberty TJ, Kelly KM, Gentili DR, Ferguson C (1987) A simply technique to accurately determine intrabdominal pressure. Crit Care Med 15:1140–1142
25. Ridings PC, Blocher CR, Sugerman HJ (1995) Cardiopulmonary effects of raised intrabdominal pressure before and after intravascular volume expansion. J Trauma 39:1071–1075
26. Diebel L, Saxe J, Dulchavsky S (1992) Effect of intrabdominal pressure on abdominal wall flow. Am Surg 58:573–576
27. Mutter D, Jamali FR, Moody DL, Rodeheaver GT, Thérin M, Marescaux J (2000) The concept of protected mesh to minimize adhesion formation in intraperitoneal abdominal wall reinforcement. Preclinical evaluation of a new composite mesh. Hernia (Suppl 4):S3–S9
28. Bellon JM, Garcia-Carranza A, Jurado F, Garcia-Honduvilla N, Carrera-San Martin A, Bujan J (2001) Peritoneal regeneration after implant of a composite prosthesis in the abdominal wall. World J Surg 25:147–152
29. Balique JG, Alexandre JH, Arnaud JP, Benchetrit S, Bouillot JL, Fagniez PL, Flament JB, Gouillat C, Jarsaillon P, Lepére M, Magne E, Mantion G (2000) Intraperitoneal treatment of incisional and umbilical hernias: intermediate results of a multicenter prospective clinical trial using an innovative composite mesh. Hernia (Suppl 4):S10–S16
30. Ammaturo C, Bassi G (2004) Surgical treatment of large incisional hernias with an intraperitoneal parietex composite mesh: our preliminary experience on 26 cases. Hernia 8(3):242–246
31. Rives J, Pire JC, Flament JB, Covers G (1977) Traitment des éventration. In: Techniques chirurgicales, Paris: Encycl Med Chir, pp 40–65