The intraabdominal pressure
A real indicator of the tension free principle during anterior wall repair procedure after incisional hernias

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AIM: *Incisional hernias represent a late onset complication of any type of laparotomy, with a relatively high incidence, and reported in 2% to 11% of all laparotomies.*
MATERIAL AND METHODS. *We performed a prospective longitudinal study that included a total number of 102 patients. The following parameters were monitored: patient history clinical findings, time of hospitalization, laboratory test results, types of surgery. Intra-abdominal pressure variations were measured using a specialized kit.*
RESULTS: *Obesity was present in 69 of the patients (67.64%). Mesh plasty was most frequently used (80.39%). The inset of the mesh was performed in onlay position (40.19%), retromuscular (29.98%) or complete defect substitution (11.76%). The correlation between the type of abdominal wall plasty, variations on the Borg dyspnea scal and likewise the correlation between the VAS (visual analogue scale) pain scale and the abdominal wall plasty procedures proved to be highly statistically significant: p< 0.001. Furthermore, the intra-abdominal pressure varied with the type of abdominoplasty carried out, reviewing the tension free principle. The most important parameter was the intra-abdominal pressure recorded at the end of the abdominoplasty, which showed significant correlations with the tension free plasties (retromuscular mesh and substitution mesh).*
CONCLUSIONS: *The tension free methods, reflected by the intra-abdominal pressure variation, were associated with a lower degree of dyspnea, low postoperative pain and less hospitalization time.*

KEY WORDS: Borg scale, Incisional hernia, Intra-abdominal pressure, Onlay, Visual analogue scale

Introduction

Postoperative incisional hernias represent a late onset complication of any type of laparotomy. These are divided into incisional hernias located on the midline, supra- and/or subumbilical (most frequent - 75%-80%), side incisional hernias after subcostal, pararectal incisions or lombotomies (lower frequency of 10%) and exceptional cases of incisional hernias after Pfannenstiel incision and trauma[1]. Since the beginning of the last century, various classical methods were developed to restore the parietal defect. Due to the high rate of relapse, they are no longer used nowadays only in the case of very specific indications[2,3].

An important historical moment in the world of surgical techniques was the reconstruction of the abdominal wall using a synthetic material, polyethylene mesh, a procedure which was first carried out in 1956 by Usher. Good postoperative results recorded, entitled him to be

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known as the father of the "tension free" principle[4]. This principle is the basis of any modern day abdominal wall plasty.
The purpose of the study, is to trace the correlations between four methods of abdominal wall reconstruction, clinical and biological parameters, and intra-abdominal pressure (IAP) variation, evaluated pre and postoperatively.

Material and Methods

This study is a prospective longitudinal study. It was performed in 2014 (starting 15th May until 15th August), and enrolled 102 patients. Before beginning the study, it was obtained the agreement from the institution where the study was carryout, Tirgu Mures Emergency County Hospital, signed by the manager of the hospital and also by the head of the Surgical Clinic No.2. The document is registered in hospital archive with no. 125/2014. From all patients included into the study, it was obtained before surgery a specific informed consent. The following parameters of the patients included in the study were recorded: demographics (age, sex) and clinical findings, types of surgery and intra-abdominal pressure measurement.
Clinical findings recorded for each patient were: type of patient presentation in surgical services (chronic or emergency with acute symptoms usually associating with bowel obstruction), location of incisional hernia (median, subcostal and lateral). The degree of obesity was assessed by calculating body mass index (G/I^2). Dyspnea was assessed both preoperatively and postoperatively at discharge. Because postoperative assessment could not be performed due to restrictions of sustained efforts, we used a subjective dyspnea scale, the Borg dyspnea scale with a standardized effort (100m walking). Given that the same patient was evaluated both preoperatively and postoperatively on the same dyspnea scale, data obtained was suitable for statistical processing. Postoperative pain could be evaluated subjectively using a visual analogue scale in five units (VAS).
Recorded types of surgery were as follows: simple plasty, onlay mesh, retromuscular position and substitution mesh. In the simple plasties patient group we included the reconstructions of the abdominal wall by simple suture or overlapping the edges of muscular abdominal wall. The onlay polypropylene mesh position was used to secure a simple plasty. In the category of retromuscular mesh positioning we included the patients which had undergone the placement of the mesh inside the rectus abdominis sheath, behind the muscle, using also a part of the hernia sac. In the substitution mesh group we included the patients with complete replacement of the parietal defect with polypropylene mesh applied only over a peritoneal flap from the hernia sac.
Choosing the type of plasty for the abdominal wall depended firstly of the size of the defect and also of other factors like: age, profession, the presence of obesity and contraindications of using mesh. Thus, for defects of less than 4 cm, simple plasty was used for young patients (<50 years of age) without obesity or professions which require using of the abdominal wall, plasty onlay for those patients which had associated, the age factor (>50 years old) and retromuscular plasty, when was associated at least two factors favoring the increase of IAP: age ± obesity ± profession. For those defects bigger than 4 cm, a retromuscular plasty was used, using in the procedure and the hernia sac and substitution mesh plasty in case of which the musculoaponeurotic margins are of a good quality, being useless the dissection of the sheathes of the rectus abdominis.
Appreciation of the parietal defect was made intraoperatively after preparing the hernial sac and abolition of all the eventration orifices.
The intra-abdominal pressure measurement was made using a specialized kit (Abviser ABV 611). It is an indirect method, using the urinary bladder wall as a pressure transducer between the abdominal cavity and urinary bladder (Fig. 1). Abdominal pressure values were consistently recorded in the following manner.
IAP1 - abdominal pressure value recorded after the patient was anesthetized, with complete induced muscle paralysis, but before incision. This was used as the reference value.
IAP2 - abdominal pressure value recorded after the incision, adhesions dissolution and after removing the small bowel, so that the bladder remains free.
IAP3 - abdominal pressure value recorded after restoration of intestinal loops and omentum in the peritoneal cavity.
IAP4 - abdominal pressure value recorded during parietal reconstruction.
IAP5 - abdominal pressure value recorded at the end of the muscular wall plasty with or without mesh, with patients still in complete muscular paralysis.

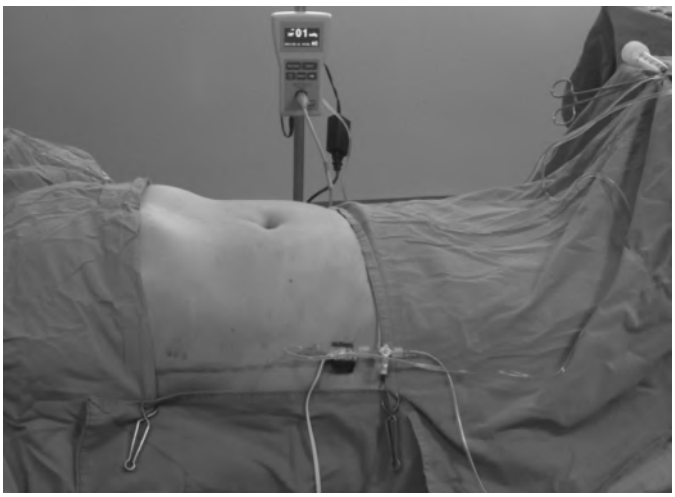

Fig. 1: Measurement of intraabdominal pressure using the Abviser ABV 611 kit.

IAP6 - the value recorded after closing the subcutaneous tissue and the skin with the patient still in complete muscle relaxation conditions. This represents the weight of the subcutaneous tissue and skin tightening after the suture.
Intra-abdominal pressures IAP1, IAP2 and IAP3 are not influenced by the size of the defect. Statistical processing of the three parameters were precalculated in relation to the chosen procedure.
IAP4, IAP5, IAP6 represented parameters whose variations depended on the size of the defect and statistical processing was carried out in relation to the type of reconstruction, dividing the study group in two categories: defects smaller than 4 cm and defects bigger than 4 cm. Thus, IAP4, IAP5, IAP6, IAP4-IAP1, IAP5-IAP1 were compared for defects smaller than 4 cm for the simple plasty, onlay and retromuscular and for bigger than 4 cm the retromuscular plasty and substitution mesh plasty.
For the statistical analysis of the collected data it was used the Data Analysis module from Microsoft Excel (Student's T-test, ANOVA single factor test). The significance threshold was set at 0.05.

Results

Statistical processing of the collected data revealed important results. In the studied group, the distribution by age and sex indicated the presence of hernia in females with preponderance in a ratio of 72.54 %, for the age group between 61-70 years old. Regarding the location of the parietal defect, most patients presented postoperative incisional hernias of the midline, over or subumbilical sites (95 cases).
Obesity, a contributing factor of the hernia disease, was present in a total of 69 patients (67.64%), in varying degrees, being more common in women (74.21 %) than in men (51.46 %).
In the majority of cases, the surgical procedure was the abdominal wall plasty with polypropylene mesh (80.39 %), while a smaller percentage (19.61 %) were simple plasties. The onlay position was used most often, in a total of 41 cases (40.19 %), followed by retromuscular position in 31 cases (29.98 %), while the complete substitution of the parietal defect using a mesh, in 12 patients (11.76 %).
For each procedure carried out, it was calculated the medium parietal defect (MPD). Thus, for simple plasty MPD=2.33 cm, for onlay plasty MPD=3.44 cm, for retromuscular plasty MPD=5.58 cm and for substitution mesh plasty MPD=12.66 cm.
Preoperative dyspnea was assessed using the Borg scale, including the patients into several groups of dyspnea. The dyspnea underwent postoperative changes and, in most cases, there was a jump in the degree of dyspnea at a higher level, but not statically significant (p=0.23) (Figg. 2, 3).

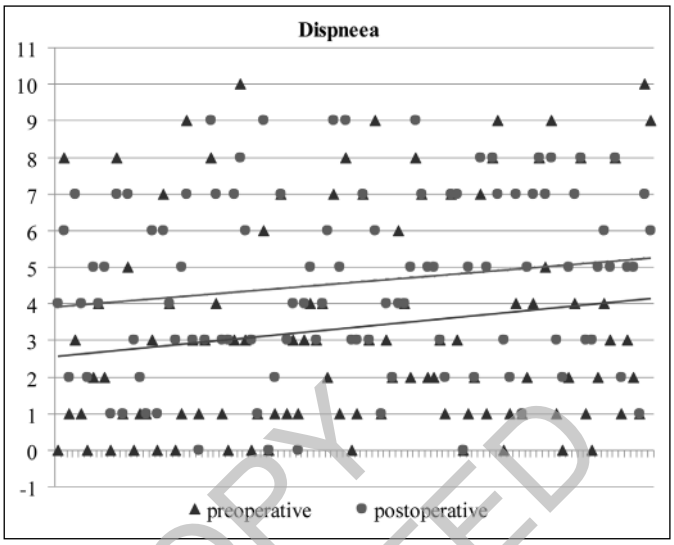

Fig. 2: The "jump" of postoperative dyspneea on Borg scale.

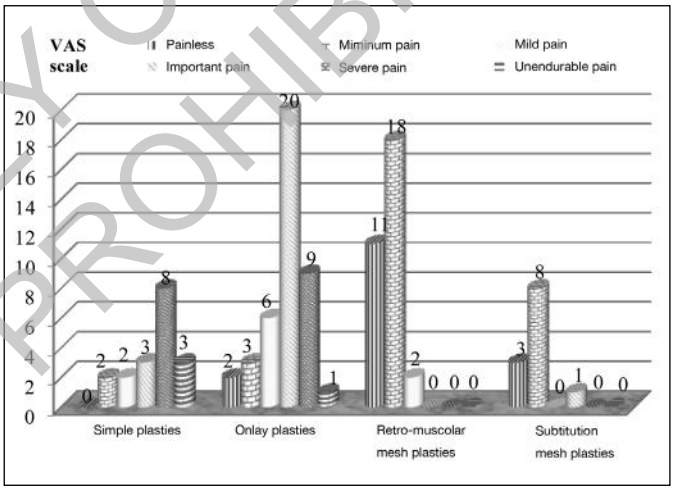

Fig. 3: VAS correlated with the types of plasties.

After assessing all four procedures using the pain VAS, the patients were divided into six subgroups. VAS correlation with the type of abdominal wall plasty showed a high statistical significance: p< 0.001.
Duration of hospitalization was between 5 days and 19 days.
Average hospitalization for the simple plasty group was 8.47 days, 9.95 days in case of the onlay mesh plasty group, 6.45 days for retromuscular mesh plasties and 6.25 days for the substitution mesh plasty group.
IAP1 ranged from 1 to 15 mmHg, with an average of 4.568. Differences between IAP1 with the four techniques were not statistically significant, but could be correlated with the degree of obesity (calculated correlation coefficient, r = 0.267). Also, IAP1 recorded significantly higher values $IAP1_m$ = 12.891 (p< 0.001) in case of patients admitted and operated in emergency, those which were associated with intestinal occlusion.

TABLE I - *Correlations between the four methods with the variable as IAP5-IAP1 and medium parietal defect (MPD)*

MPD	Type of plasty	N.	Sum	Media	Variation	P Value
MPD< 4 cm	Simple plasty	18	34	1.888	6,575	P<0.001
	Onlay plasty	41	107	2.609	1,993	
	Retro-muscular plasty	14	-2	-0,142	0,901	
MPD>4 cm	Retro-muscular plasty	16	-19	-1.187	7,362	P= 0.403
	Substitution mesh plasty	11	-5	-0.454	1,072	

IAP2 pressure recorded after the release of adhesions and intestinal loops, ranged from 0 to 6, with an average of 1.862. IAP2 - IAP1 difference was significantly higher (-8.444 from -2.150) in case of patients admitted in emergency, with associated intestinal occlusion (p< 0.001).
IAP3 pressure after intestinal loops restoration varied very little from IAP2 ($IAP3_m$ = 2.186), except in cases with intestinal occlusion where IAP3 - IAP2 = 0.55556, compared to IAP3 - IAP2 = 0.30108 in chronic cases; the difference was not statistically significant (p= 0.348). Also, there were no statistically significant differences between IAP3 values measured during the performed procedures.
IAP4 pressure recorded during abdominal wall plasty varied between 0 and 10. The IAP4 - IAP1 difference represents the effect of partial abdominoplasty on intra-abdominal pressure. It was the first indicator of a tension free plasty.
IAP4 - IAP1 difference in the four methods showed a minor increase for retromuscular mesh procedure and the substitution mesh compared to simple plasty and onlay mesh but with no statistically significance.
IAP5 pressure recorded at the end of the abdominal wall plasty under conditions of complete relaxation ranged between 2 and 6 (average of 5.705). The IAP5 - IAP1 difference represented the most important parameter in evaluating the abdominal wall defects plasty and can be considered a real indicator of the tension free principle assessment.
When comparing IAP5 - IAP1 values between the four types of abdominoplasty, we found elevated tension (IAP5 - IAP1 = 1.888) in case of the simple plasty and in case of the onlay position mesh (IAP5 - IAP1 = 2.609). The difference was lower in case of the retromuscular plasty (IAP5 - IAP1 = - 0.142 for MPD≤4 cm and IAP5-IAP1= -1.187 for MPD>4 cm) and a minimum difference was observed in substitution mesh plasty (IAP5 - IAP1 = - 0.454).
Also, by analyzing the four methods, we found both significant and non-significant differences in evaluation of the tension free principle Table I.
IAP6 pressure recorded at the end of surgery, after suturing the subcutaneous tissue and skin, keeping the myorelaxation, ranged between 2 and 18, with an average of 6.637. Major changes occurred in patients with 2nd and 3rd degree obesity, but not statistically significant (p = 0.798). This difference did not vary significantly (p= 0.636) between the four types of procedures.

Discussion

The evolution of postoperative hernias underwent important changes in the last two decades by the contribution of suture materials and the meshes used for abdominal wall plasty[5,6]. Increased physical effort is the main etiological factor in the pathogenesis of incisional hernias, correlated with postoperative local factors[6,7]. Neither age, nor sex could be established as predisposing factors for postoperative hernias. Occlusive complications (incarceration, strangulation – 6% rate) require urgent surgical approach. Intestinal obstruction worsens the postoperative course and can change the choice of abdominal wall plasty procedure[6] . Obesity is a risk factor of postoperative hernias. World Society of Abdominal Compartment Syndrome has set the upper limit value of 5-7 mmHg for intra-abdominal pressure. However, in people with obesity or those with chronic obstructive pulmonary disease, the accepted values are up to 12 mmHg[8,9]. In our study, the absence of obesity has been found in 33 cases and its presence in 70 cases. The relationship between the postoperative hernia and dyspnea was explained by the occurrence of paradoxical movements of the hernia sac, more or less affecting the respiratory parameters, depending on the size of the defect and hernia sac[10]. Dyspnea may be also a symptom due to obesity or individual associated cardio-pulmonary conditions. The relationship between dyspnea and abdominal wall plasty is more important. The tension free procedure (retromuscular mesh, substitution mesh) produces minimal changes in respiratory parameters[11], while procedures performed with high parietal tension, present varying degrees of dyspnea or sometimes even the impossibility of disconnecting the patient from the mechanical ventilation unit[11]. In the study group, when assessing dyspnea, we used a subjective scale - revised Borg scale (10 steps)[12]. Postoperative pain depends on many factors: parietal tension, nerve involvement in suture or dissection and individual pain threshold[13,14].
Mesh insertion into the rectus abdominis sheath was the preferred choice, whenever the local conditions allowed dissection of sheaths.

Intra-abdominal pressure (IAP) translates into pressure recorded within the peritoneal cavity between its organs[15]. The concept of intra-abdominal pressure, intra-abdominal hypertension, abdominal compartment syndrome was established in 2004 after the International Congress of Anaesthesia and Intensive Care, the time when the World Society of Abdominal Compartment Syndrome (WSACS) was founded[15]. Intra-abdominal pressure (IAP) should not normally exceed 12 mmHg, determined by three repeated measurements 4-6 hours apart[16]. Intra-abdominal hypertension (IAH) is defined by three values recorded every 4-6 hours, ranging from 12 to 20 mmHg. Abdominal compartment syndrome (ACS) occurs when intra-abdominal pressure exceeds 20 mmHg also associating single or multiple organ dysfunction[16,17].

In our study the most important component of assessing the tension free principle was the IAP5 - IAP1 difference which indicates the increase of IAP after abdominal wall plasty. Also IAP4 - IAP1 can be a guiding element for the surgeon performing surgery of the abdominal wall. IAP4 - IAP1 difference, if is progressive, should require, if possible, the choice of another method of abdominal wall plasty.

Obesity is a risk factor of incisional hernia. The IAP - obesity relationship could be demonstrated in our study through the difference IAP6 - IAP5 which means the overlapping of the subcutaneous tissue. IAP6 – IAP5 varied, but the statistical comparison results in p= 0.675.

Conclusions

The most common postoperative incisional hernias were those of the midline. The procedures that followed the tension free principle were associated with a slight progression of postoperative dyspnea.

Indirect measurement of abdominal pressure using the urinary bladder approach could assess the degree of tension of the abdominal wall plasty (evaluation of tension free principle).

For close values of medium parietal defect there were registered important statistically significant differences between three of procedures (simple plasties, onlay plasties, retromuscular plasties).

The tension free methods were associated with a lower degree of dyspnea, low postoperative pain

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Riassunto

INTRODUZIONE: Le eventrazioni postoperatorie rappresentano una complicanza remota della laparotomia di qualsiasi tipo con un'incidenza relativamente alta, tra il 2-11% del totale in letteratura. Un momento importante nella storia delle plastiche della parete addominale è rappresentato dall'introduzione di Usher delle reti sintetiche nel 1958.

MATERIALE E METODO: Studio longitudinale prospettico, condotto nel periodo maggio – agosto 2014, con l'inclusione di 102 pazienti, in conformità con le norme etiche, e consenso informato postoperatorio di tutti i pazienti, e l'approvazione della direzione dell'unità operativa sede dello studio. Nei pazienti arruolati nello studio sono stati presi in considerazione diversi parametri: individuali, clinici, durata del ricovero, paraclinici, tipo d'intervento, variazioni di pressione intra-addominale e complicanze postoperatorie. La dispnea e il dolore postoperatorio sono stati monitorati attraverso scale analogiche (scala di Borg della dispnea e Visual Analogue Scale per il dolore). I tipi di intervento chirurgico sono stati suddivisi tra procedure senza rete e procedure alloplastiche (onlay, plastica con rete retro muscolare e plastica con rete di sostituzione). La pressione intra-addominale è stata misurata in modo indiretto, trans-vescicale, attraverso un kit dedicato, in 6 momenti postoperatori standard.

RISULTATI: Con l'elaborazione statistica dei risultati si è rilevata una preponderanza delle eventrazioni postoperatorie nel sesso femminile (72,5%) nella fascia di età 61-70 anni. L'obesità è risultato un fattore favorente la comparsa delle eventrazioni.

Le procedure più eseguite sono state le plastiche con rete (80,3%), di cui la variante onlay quella preferita. La dimensione media del difetto parietale è stato di 2,33 cm per le plastiche semplici, 3,44 cm per quelle onlay, 5,58 cm per quelle con rete retro muscolare e 12,66 cm per le plastiche con rete di sostituzione. La valutazione pre e postoperatoria della dispnea ha fatto rilevare un modesto incremento di intensità nel postoperatorio. Il dolore postoperatorio è stato significativamente correlato dal punto di vista statistico con le procedure eseguite, essendo ridotto nei casi in cui è stato rispettato il principio "tension free". Questo principio è stato valutato più accuratamente con la differenza fra la pressione intra-addominale alla fine e all'inizio dell'operazione. In questo modo, le procedure semplici e onlay sono state associate con variazioni positive elevate della pressione addominale, mentre le procedure con la rete retro muscolare e di sostituzione completa del difetto con variazioni minime. Le differenze tra le procedure sono state significative dal punto di vista statistico (p <0,001).

DISCUSSIONE: Lo sforzo fisico sostenuto associato oppure no ai fattori locali, rappresenta i principali fattori che favoriscono la comparsa delle eventrazioni postoperatorie. L'esecuzione delle plastiche della parete addominale

con un alto grado di tensione è stato constatato per grandi variazioni della pressione intra-addominale, per la compliance della parete muscolo-aponeurotica, che può mantenere constante la pressione intra addominale fino al raggiungimento di una soglia critica, oltre la quale aumenta bruscamente. L'aumento di intensità della dispnea postoperatoria è determinata all'ascensione del diaframma nelle procedure eseguite sotto tensione, ma anche al dolore collegato alla stessa causa.

CONCLUSIONI: La misura indiretta della pressione intra-addominale in via trans vescicale ha rappresentato un elemento di valutazione obiettiva del grado di tensione delle plastiche della parete addominale. Il principio "tension free" ha comportato un grado ridotto di dispnea e di dolore postoperatorio. Le variazioni preoperatorie di pressione intra-addominale sono state significative dal punto di vista statistico tra le quattro procedure di plastica della parete addominale.

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