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Measurement of intra-abdominal pressure in large incisional hernia repair to prevent abdominal compartmental syndrome

A.M. ANGELICI, B. PEROTTI, C. DEZZI, C. AMATUCCI,
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SUMMARY: **Measurement of intra-abdominal pressure in large incisional hernia repair to prevent abdominal compartmental syndrome.**

A.M. ANGELICI, B. PEROTTI, C. DEZZI, C. AMATUCCI, G. MANCUSO, R. CARONNA, P. PALUMBO

Introduction. *The repair of large incisional hernias may occasionally lead to a substantial increase in intra-abdominal pressure (IAP), and rarely to abdominal compartmental syndrome (ACS) with subsequent respiratory, vascular, and visceral complications. Measurement of the IAP has recently become a common practice in monitoring critical patients, even though such measurements were obtained in the early 1900s.*

Patients and Methods. *A prospective study involving 54 patients undergoing elective abdominal wall gap repair (mean length, 17.4 cm) with a tension-free technique after incisional hernia was conducted. The purpose of the study was to determine whether or not urinary pressure for indirect IAP measurement is a reliable method for the early identification of patients with a higher risk of developing ACS. IAP measurements were performed using a Foley catheter connected to a HOLTECH® medical manometer. IAP values were determined preoperatively, after anesthetic induction, upon patient awakening, upon patient arrival in the ward after surgery, and 24 h after surgery before removing the catheter. All patients were treated by the same surgical team using a prosthetic composite mesh (PARIETEX®).*

Results. *Incisional hernia repair caused an increase in the mean IAP score of 2.68 mmHg in 47 of 54 patients (87.04%); the IAP was decreased in two patients (3.7%) and remained equal in five patients before and 24 h after surgery (9.26%). FEV-1, measured 24 h after surgery, increased in 50 patients (92.6%), remained stable in two patients (3.7%), and decreased in two patients (3.7%). The mean increase in FEV-1 was 0.0676 L (maximum increase = 0.42 L and minimum increase = 0.01 L) in any patient who developed ACS.*

Conclusions. *Measurement of urinary bladder pressure has been shown to be easy to perform and free of complications. Measurement of urinary bladder pressure can also be a useful tool to identify patients with a higher risk of developing ACS.*

KEY WORDS: Incisional hernia - Intra-abdominal pressure - Compartmental syndrome.

Introduction

An incisional hernia is a protrusion of the abdominal viscera through a leak in the abdominal wall that develops after a surgical incision. Incisional hernias represent the most common wound complication, with a reported incidence between 10% and 20% (1). Among all incisional hernias, 75%-90% occur on the median line (2, 3).

The incidence of incisional hernias depends on different factors, including age, gender, obesity, emergency or elective surgery, suture length and type, concomitant respiratory disease, and abdominal distension (4).

Repair of large incisional hernias (>10cm) with closure of the parietal defect restores adequate intra-abdominal pressure (IAP) (5). This procedure can occasionally cause a substantial increase in the IAP with subsequent respiratory, vascular, and visceral complications that could lead to abdominal compartmental syndrome (ACS) (6-9). Measurement of the IAP has recently become a common practice in monitoring critical patients, even though measurement of the IAP has been utilised since the early 1900s (10, 11). The main purpose of this prospective study was to focus on abdominal pressure changes in patients who underwent surgery for repair of large incisional hernias using a double face mesh placed intraperitoneally with a tension-free technique.

The aim of this study was to determine whether or

Department of Surgical Sciences,
"Sapienza" University of Rome, Rome, Italy

Corresponding Author: Piergaspare Palumbo,
e-mail: piergaspare.palumbo@uniroma1.it

not urinary pressure measurement is a reliable method for the indirect measurement of IAP. Furthermore, in patients who undergo prosthetic surgery for reconstruction of abdominal wall gaps, urinary pressure measurement can be predictive for the development of ACS.

Patients and methods

IAP measured at a single point of the abdomen can be assumed to be the pressure throughout the abdominal cavity according to Pascal's Law (11). The IAP can be measured directly using a needle puncture of the abdomen during peritoneal dialysis or laparoscopy, or indirectly measuring the transduction of intra-urinary bladder, colonic or uterine pressure via a balloon catheter either intermittently or continuously (12-19).

The most frequent method used for indirect measurement of IAP is the intra-urinary bladder method because the bladder wall acts as a passive diaphragm when inflated with a small amount of normal saline solution (80-100 mL) and can thus be an indicator of IAP.

The standard method for IAP measurement is the intermittent intra-urinary bladder measurement proposed by Kron (18); specifically, a urinary (Foley) catheter is placed and the urinary bladder is emptied, and 80-100 mL of sterile normal saline solution is instilled through the catheter. Several studies have shown that high volumes may increase urinary bladder pressure, especially at higher IAPs, such that measurements no longer reflect true abdominal pressure (14). The catheter is connected to a pressure transducer placed at the level of the symphysis pubis, or as most recently recommended, on the mid-axillary line estimated as basal.

IAP should be expressed in mmHg and measured at end-expiration in the supine position, thus ensuring the absence of abdominal muscle contraction (14).

Between January 2012 and February 2014, 54 patients (M:F=31:23; age range, 49-79 years; mean, 68.28 years) with large post-incisional hernias (mean length, 17.04 cm; range, 12-20 cm) were treated surgically using a double-face mesh placed intraperitoneally with a tension-free technique and submitted to IAP monitoring using the transvesical method. In all cases, the post-incisional hernia was a consequence of a median xyfopubic access.

Pre-operatively, patients underwent the following testing:

- routine clinical studies (CBC, renal function, hepatic function, and coagulation);
- ECG and cardiologic evaluation (Goldman criteria);
- spirometry;
- abdominal wall ultrasonography;
- pre-anesthetic evaluation (American Society of Anesthesiologists scale).

IAP measurements were performed using a Foley catheter connected to a HOLTECH® (Holtech Medical, Charlottenlund, Denmark) medical manometer. All measurements were performed by the same operator to avoid discrepancies caused by different techniques.

The IAP values were detected as follows:

- pre-operatively (basal level);
- after anesthetic infusion;
- upon patient awakening after surgery;
- upon patient arrival in the ward after surgery with a continuous infusion of analgesics;
- 24 h after surgery before removing the catheter.

Values between 0 and 12 mmHg were considered to be normal according to the intra-abdominal hypertension (IAH) grading score (Table 1).

To prevent ACS, the forced expiratory volume in the 1sts (FEV-1) before and 24 h after surgery was measured, comparing the variation with IAP variations measured at the same time.

A nasogastric tube was placed intra-operatively and removed during the 1st post-operative day in all cases.

All patients underwent elective surgery by the same surgical team using a similar surgical tension-free technique.

An intraperitoneal prosthetic composite mesh (PARIETEX®; Covidien) was anchored at least 5 cm from the gap margin. To ensure blockage of the mesh, a spiral absorbable fixation device was used (AbsorbaTack®; Covidien). Component separation was performed in all cases (21).

A drainage tube in vacuum conditions was inserted in the subcutaneous layer in all cases, and removed on post-operative day 2. Twenty-four hours after surgery, the bladder catheter was removed. All patients were discharged on the 5th post-operative day.

Post-operative pain was controlled using an intravenous continuous infusion of ketorolac (2 mL/h).

Results

The pre-operative mean IAP was 10.9 mmHg (maximum value = 12 mmHg and minimum value = 5 mmHg). After anesthesia induction, the mean IAP score was 6.8 mmHg (maximum value = 10 mmHg and minimum value = 4 mmHg). The mean IAP measured at the end of surgery was 12.1 mmHg (maximum value = 15 mmHg and minimum value = 10 mmHg). Twenty-four hours after surgery, the mean IAP was 11.25 mmHg (maximum value = 14 mmHg and minimum value = 8 mmHg). All values reported above are highlighted in Table 2.

TABLE 1 - ABDOMINAL WALL DEFECT, FEV-1 MEASUREMENTS AND IAP MEASUREMENTS.

Patient	Wall defect	Pre-operative FEV-1	Post-operative FEV-1	Pre-operative IAP	IAP after anesthetic infusion	Post-operative IAP	IAP at patient's admission in the ward	IAP 24 hours after surgery	IAP variation	FEV-1 variation
n	cm	L	L	mmHg	mmHg	mmHg	mmHg	mmHg	mmHg	L
1	20	2,84	2,89	11	8	15	12	11	0	0,03
2	17	2,21	2,28	8	6	11	10	8	0	0,07
3	12	2,35	2,37	10	7	12	9	8	-2	0,02
4	15	1,84	2,22	11	6	13	10	9	-2	0,38
5	18	2,13	2,55	7	5	14	12	13	5	0,42
6	16	2,34	2,42	8	6	15	13	12	4	0,09
7	12	3,03	3,14	11	9	12	12	12	1	0,11
8	14	2,6	2,65	10	7	13	12	11	1	0,05
9	20	2,13	2,34	7	6	15	13	13	5	0,21
10	14	3,11	3,32	9	7	11	10	10	1	0,21
11	13	1,97	2,02	11	10	12	12	12	1	0,05
12	17	2,78	2,82	7	6	13	11	11	4	0,04
13	19	2,25	2,29	8	6	12	11	10	2	0,04
14	12	2,14	2,23	12	10	14	13	12	0	0,09
15	18	3,13	3,18	9	7	13	13	12	3	0,05
16	14	2,41	2,43	9	7	12	11	10	1	0,02
17	19	3,15	3,12	6	4	15	13	14	8	-0,03
18	14	2,92	2,94	9	7	11	10	10	1	0,02
19	13	3,01	3,05	10	8	12	11	11	1	0,04
20	16	2,89	2,9	10	7	11	10	11	1	0,01
21	15	1,82	1,84	8	6	12	13	10	2	0,02
22	20	2,32	2,33	6	4	10	11	10	4	0,01
23	13	1,87	1,87	9	7	11	10	10	1	0
24	15	2,04	2,1	8	6	13	12	11	3	0,06
25	12	2,17	2,15	10	7	12	11	11	1	0,02
26	15	2,67	2,7	11	9	13	12	12	1	0,03
27	17	2,57	2,63	6	5	15	14	13	7	0,06
28	20	3,01	2,99	5	4	14	15	14	9	-0,02
29	15	2,87	2,94	10	7	11	10	10	0	0,07
30	13	2,13	2,17	11	9	13	12	12	1	0,04
31	15	2,99	3,01	9	7	13	11	11	2	0,02
32	14	1,86	1,89	11	9	14	12	12	1	0,03
33	18	2,66	2,81	7	6	13	12	11	4	0,15
34	16	1,93	1,99	10	8	12	10	10	0	0,06
35	19	2,55	2,55	6	5	13	11	11	5	0
36	15	1,87	1,93	9	7	12	13	11	2	0,06
37	13	2,12	2,2	10	7	12	11	11	1	0,08
38	15	2,27	2,31	9	7	12	12	11	2	0,04
39	14	1,92	2,01	10	9	12	11	11	1	0,03
40	17	2,37	2,47	7	4	10	9	8	1	0,1
41	16	2,69	2,78	10	8	12	12	11	1	0,09
42	14	2,75	2,83	9	7	13	12	12	3	0,08
43	18	3,04	3,05	7	5	13	14	12	4	0,01
44	17	2,83	2,89	8	6	14	12	11	3	0,06
45	16	1,87	1,98	10	8	12	11	11	1	0,11
46	13	2,11	2,22	11	8	13	11	11	1	0,11
47	18	2,93	3,02	7	6	13	14	12	5	0,09
48	20	2,77	2,89	6	4	13	12	11	5	0,12
49	16	1,98	2,01	8	7	12	11	11	3	0,03
50	12	2,05	2,14	12	10	14	13	13	1	0,09
51	14	2,53	2,61	10	8	12	11	11	1	0,08
52	16	3,09	3,12	9	7	13	12	11	2	0,03
53	19	2,96	3,03	7	5	14	11	10	3	0,07
54	20	2,52	2,54	6	4	13	13	12	6	0,02

TABLE 2 - INTRAABDOMINAL HYPERTENSION GRADING SCALE.

Grade	Intraabdominal Pressure
1	12-15 mmHg
2	16-20 mmHg
3	21-25 mmHg
4	> 25 mmHg

The FEV-1 was increased in 50 patients (92.6%), remained stable in two patients (3.7%), and decreased in two patients (3.7%). The mean increase in FEV-1 was 0.0676 L (maximum increase = 0.42 L and minimum increase = 0.01 L).

Incisional hernia repair caused an increase in the mean IAP score (2.68 mmHg) in 47 of 54 patients (87.04%), a decrease in the mean IAP score in two patients (3.7%), and the mean IAP score remained equal before and 24 h after surgery in five patients (9.26%).

All of the patients who underwent surgery during our study did not develop ACS.

As reported above FEV-1 decreased from the pre-operative FEV-1 level in two patients (0.03 L lost in the first patient and 0.02 Lin the second patient) (Figure 1). The abdominal wall defects present in these two patients were two of the widest defects found in our study (20 cm in the first patient and 19 cm in the second patient). The IAP 24 h after surgery increased in both patients from the IAP measured before surgery (9 mmHg gained in the first patient and 8 mmHg in the second patient).

Discussion and Conclusions

Post-incisional hernias represent one of the most frequent late complications in patients after laparotomy (10%-20%; 1).

The surgical approach becomes complex when the dimensions of the abdominal wall defect can determine the onset of important physiopathologic modifications that lead to ACS (14).

IAP can increase under high-tension abdominal wall closure and can be the reason of complications, such as recurrences, post-operative pneumonia, and respiratory insufficiency; however, the large diffusion of prosthetic biomaterials used to obtain a valid reconstruction of the abdominal wall using a tension-free technique has reduced the incidence of such complications (1, 20).

An important way to prevent IAH is the choice of surgical technique, which should guide the surgeon through the appropriate selection of mesh dimensions, type, and intra-abdominal positioning. Evidence obtained in-

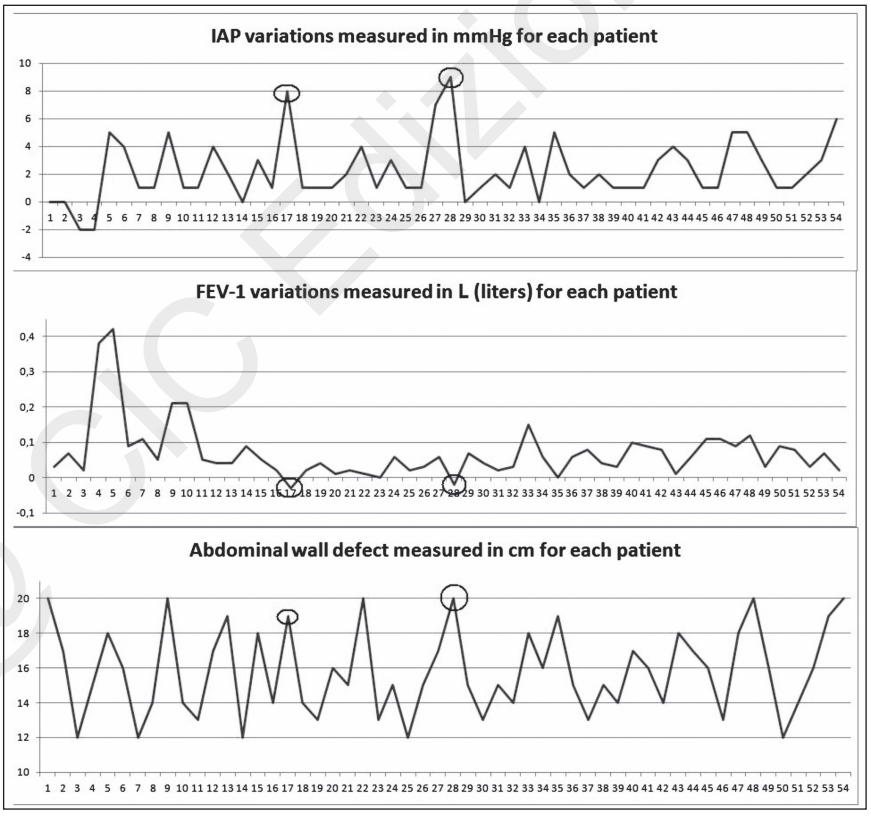

Fig. 1 - Correlation between IAP variations, FEV-1 variations and abdominal wall defect for each patient.

tra-operatively and based on the possibility of a correct peritoneal plain reconstruction should guide the choice of mesh dimension without causing a significant increase in the IAP (1). The intraperitoneal approach, the fixation of the mesh with a spiral fixation device, and the eventual component separation can ensure good results with respect to IAH control.

Measurement of urinary bladder pressure has been shown to be a good system to assess abdominal pressure after incisional hernia repair and to be predictive of ACS. In some cases, such as a neurologic or contracted bladder, outflow obstruction, bladder trauma, abdominal packing, or abdominal adhesion, IVP measurement may not accurately reflect IAP. Patients included in our study were not under similar conditions (12, 14, 19).

Incorrect interpretations can be obtained when measurements are obtained in non-supine positions, and more often, in patients with an increased BMI. Therefore, each measurement was repeated three times and only the average value was considered valid.

The authors did not report any urinary infectious complications related to the bladder catheter.

IVP measurement can be considered the gold standard for indirect measurement of the IAP in clinical practice because it is minimally invasive, inexpensive, easy to perform, safe, and well-accepted by the patients (18).

A small increase in the IAP is considered to be a physiologic response to incisional hernia repair. All patients presented a grade 1 IAH immediately after the post-operative period; however, an increase in the IAP that leads to an IAH grade > 2 is predictive of ACS development. The authors suggest the choice of an intraperitoneal prosthetic composite mesh fixed with absorbable devices to prevent an increase in IAP that could lead to an IAH grade > 1.

Comparing IAP variations to FEV-1 modifications could be a reliable method to validate incisional hernia repair with a tension-free technique.

FEV-1 increased in 92.6% of the patients; however, the FEV-1 decreased following large wound defect repairs. We ascribe this finding to a sudden increase in the IAP due to the incisional hernia repair, and suggest that the impressive correlation between the increase in IAP and decrease in FEV-1 would be a useful method for the early diagnosis of ACS.

Additional studies involving a larger number of patients and different types of incisional hernia should follow this evidence.

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