UNIVERSITY OF MEDICINE AND PHARMACY

„ CAROL DAVILA" BUCHAREST

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PREDICTION, PREVENTION AND MANAGEMENT OF INTRA-ABDOMINAL HYPERTENSION SYNDROME ASSOCIATED WITH INCISIONAL HERNIA SURGERY

PHD THESIS SUMMARY

PhD coordinator:

CONF. UNIV. Dr. MATEȘ IOAN NICOLAE

PhD student:

COȚOFANĂ ION MARIUS

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LIST OF ABREVIATIONS

- ACS Anterior component separation
- ASA American Society of Anaesthesiologists classification
- AST Anterior separation technique
- AC Abdominal compliance
- CT Computer tomography
- MTD Maximum transverse diameter
- IAH Intra-abdominal hypertension
- DIH Difficult incisional hernia
- BMI Body mass index
- L liters
- LAD Loss of abdominal domain
- PEEP Positive End-expiratory Pressure
- IAP Intra-abdominal pressure
- ICP Intracranial pressure
- ITP Intra-thoracic pressure
- PIP Peak inspiratory pressure
- APP Abdominal perfusion pressure
- PPP Progressive pneumoperitoneum
- GFR Glomerular filtration rate
- SCA Abdominal compartment syndrome
- PS Physiological serum
- SIRS Systemic inflammatory response syndrome
- SOFA Sequential Organ Failure Assessment
- RAAS Renin- angiotensin- aldosterone system
- ICU Intensive care unit
- TAC Temporary abdominal closure
- TAR Transversus abdominis release
- VAC Vacuum assisted closure
- VAWC Vacuum assisted wound closure
- IAV Intra-abdominal volume
- MV Mechanical ventilation
- WSACS World Society of the Abdominal Compartment Syndrome

INTRODUCTION

The need for IAP monitoring has become evident in the practice of the general surgeon because there are multiple surgical pathologies at risk of initiating IAH [1]. Surgery of abdominal wall defects, in particular incisional hernias represents a small proportion in the etiology of IAH and SCA. In the case of DIH, the importance of IAP monitoring has become one of the central elements involved in the prevention of IAH and SCA [2]. The IAP measurement technique is still unstandardized and is subjected to experimental and clinical research, including the present study. The research was conducted on three main axes: the stratification of the complexity of incisional hernias; identification of risk factors and prevention of pressure complications; identifying the optimal method of intra-abdominal pressure measurement.

DIFFICULT INCISIONAL HERNIA

Incisional hernia is defined as the presence of a pseudotumoral formation in the abdominal wall, on the projection area of an old postoperative scar, accompanied by a defect of the musculo-aponeurotic plane [3].

The abdominal wall limits the abdominal cavity cranially up to the level of the xiphoid and costal arch, respectively caudally up to the level of the pelvis. Abdominal compliance (AC) reflects the ability of the abdomen to expand and can be expressed as the variation in IAV relative to the variation in IAP. Risk factors for low AC can be divided into the following categories: those related to the habitus and anthropometry of the body; those related to the presence of comorbidities and/or an increased and non-compressible intra-abdominal volume (IAV); those related to the abdominal wall and diaphragm [4][5]. From an etiopathogenic point of view, most of the time, the mechanisms underlying the development of IAH/SCA are represented by the ischemia-reperfusion phenomenon and visceral edema [6][7].

The loss of abdominal domain is defined variably according to the author. The most common definitions are the protrusion in the hernia sac of more than 30% of the abdominal visceral mass or as the ratio between the volume of the hernia sac and the volume of the peritoneal cavity greater than 1/3 [8][9]. Changes in IAP following reduction of large hernia sacs and restoration of the abdominal wall are mainly dependent on the operator's technique.

To prevent the occurrence of IAH/SCA following abdominal wall reconstruction, especially after large defects (MTD > 10 cm), the following strategies can be considered: decreasing the volume of the abdominal contents (by elective intestinal resection), improving AC (by neuromuscular blockage or the use of botulinum toxin A) and increasing the abdominal volume capacity (transverse division of the abdominal muscles, phrenicectomy, progressive preoperative induction of pneumoperitoneum, musculofascial flaps).

IAH DIAGNOSIS AND IAP MONITORING

Intra-abdominal pressure is the constant pressure exerted inside the peritoneal cavity by the intra-abdominal viscera and the abdominal wall. Intra-abdominal pressure monitoring technique is an often debated controversy in literature, with consensus gathered by the WSACS. The notion of "Gold Standard" in intra-abdominal pressure monitoring is often associated in the medical environment with the indirect estimation of IAP through transvesical monitoring [10].

Definitions according to Noosa-Australia 2006 [11]:

- Normal IAP $\leq$ 5 mmHg;
- IAH = IAP $\geq$ 12 mmHg;
- ACS = IAH + organ failure.

Non-invasive monitoring of intra-abdominal pressure can be achieved using imaging tools (abdominal tomography, ultrasound tonometry, abdominal radiography), indirect monitoring methods using abdominal cavitary organs (bladder, stomach, rectum and uterus) [12]. Invasive monitoring involves methods of direct measurement of intra-abdominal pressure (cannulation of the peritoneal cavity or insertion of a needle with a large diameter and connecting them to a saline manometer or pressure transducer) [13].

PHYSIOPATHOLOGY OF INTRA-ABDOMINAL HYPERTENSION AND ABDOMINAL COMPARTMENT SYNDROME

The pressure inside the abdominal cavity (IAP) is determined by both the mechanical characteristics of the walls and the contents of the space. Although this varies, the increase of IAP above the physiological limit of 0-5 mmHg causes the disruption of homeostasis with physiopathological effects on the organs in the abdominal cavity as well as outside it [14].

The cardiovascular system is influenced by the installation of intra-abdominal hypertension by altering preload, contractility, afterload and oxygen transport [15][16]. The respiratory system is affected too, in the case of IAH, by increasing the stiffness of the chest wall and compression of the lung parenchyma due to massive fluid resuscitation [17]. The nefarious triad (traumatic injury, fluid resuscitation, and supination) initiates alveolar damage with alveolar collapse, altered alveolar-capillary membrane gas exchange, and decreased global lung compliance. The pathophysiology of renal injury is multifactorial and includes: SIRS with multiple organ failure, reduced cardiac output, increased renal venous pressure, and increased renal parenchymal pressure [18][19]. Physiological changes cause activation of SRAA with initial maintenance of GFR. The increase of low blood perfusion with the overcoming of the compensatory capacity finally leads to the decrease of GFR [20]. The increase in IAP causes severe acidosis in the intestinal mucosa, decreases in hepatic and microvascular arterial flow, and increased intracranial pressure [21][22].

MANAGEMENT OF INTRA-ABDOMINAL HYPERTENSION AND ABDOMINAL COMPARTMENT SYNDROME

Correctly applied, early conservative treatment prevents the need for surgery. If conservative treatment is ineffective, the prognosis of the patient is worse, due to an increased morbidity associated with surgical decompression.

The SRTI guideline states that intra-abdominal perfusion pressure (APP) is a marker of assessment of correct volume resuscitation (performed with hypertonic and colloidal crystalloid solutions) and is characterized as the difference between mean arterial pressure and intra-abdominal pressure [23]. It is recommended that APP be maintained between 50-60 mmHg. The decision of conservative versus surgical management will be made based on consecutive measured APP.

Conservative management involves diuretic therapy, analgesia, use of neuromuscular blockers, nasogastric/colonic/percutaneous catheter decompression, paracentesis, use of octeotride (prevents the damage induced by the oxidative stress of reperfusion), melatonin (has antioxidant, anti-inflammatory properties and ability to bind the free radicals) [23][24].

Surgical/invasive management includes temporary abdominal closure (TAC), Bogota Bag temporary closure, parietal mesh closure, use of VAWC negative pressure device, decompressive laparotomy [25][26]. For the surgical treatment of incisional hernias, the Rives-Stoppa technique

(the gold-standard option), parieto-abdominal augmentation techniques, intraparietal prosthesis, associated or not with the preoperative injection of botulinum toxin, is used, which objectively facilitates the surgical management of complex hernias , having the ability to allow a tension-free myofascial suture [27][28][29].

HYPOTHESIS AND GENERAL OBJECTIVES

The first study dealt with the definition of the concept of difficult incisional hernia, based on objective criteria, i.e. the development of a difficulty score that is simple to apply and with practical relevance, considering that in the literature there are contradictory data and divergences in this regard. **The main purpose** of the study that was the basis of this work is the evaluation of the impact of the surgical intervention on the pressure dynamics inside the peritoneal cavity and its systemic impact in patients with voluminous parietal defects.

In order to systematize the study methodology, **the research objectives** were formulated:

- Identifying eligible cases and creating an electronic database;
- Identification of criteria for stratification of the complexity of incisional hernias (Study 1);
- Identifying the optimal method of measuring intra-abdominal pressure (Study 2);
- Identification of risk factors and prevention for the occurrence of complications dependent on increased intra-abdominal pressure (Study 3).

STUDY 1 - DEVELOPMENT OF A SCORE FOR DEFINING DIFFICULT INCISIONAL HERNIAS

The first study formulated was retrospective , conducted between January 1, 2015-June 1, 2018, unicentric, within the Bucharest University Emergency Hospital, Department of General Surgery III, descriptive and correlational, non-interventional. The final objective in correctly defininig of DIH is to compare the initial complexity score with the IAP obtained following monitoring, thus, through the obtained feedback, the final weighting of the independent variables is modified, thus determining a IAH prediction score with increased sensitivity. **The aim of the study** is to create the necessary tool for predicting IAH and SCA in difficult incisional hernias.

MTD	<=10	0
	>10	3
Unisacular		0
Multisacular		1
BMI	<=30	0
	>30	1
RANK	1	0
	>= 2	1
LOSS OF ABDOMINAL DOMAIN	NU	0
	DA	1

The conducted study succeeds in generating a promising incisional hernia complexity score, with statistically significant results and correlations in the specialized literature [30].

Limitations of the study were determined by:

• The complexity of the surgical intervention and implicitly the difficulty of the incisional hernia were evaluated only through the operative time;

• Heterogeneity of topographic location, except mid-abdominal incisional hernias;

• Lack of prospective evaluation of the proposed score.

Conclusions of the study were:

1. Difficult incisional hernia is a pathological entity difficult to define, which cannot be quantified by a single parameter and requires in-depth correlations in order to establish the optimal description parameters.

2. The maximum transverse diameter is the central pillar in the definition of difficult incisional hernia, but it is not sufficient as a single element.

3. The incisional hernia with loss of domain, often described by a maximum transverse diameter of over 20 cm, is difficult due to the atrophy of the latero-abdominal muscles and the

lateralization of the rectus abdominis muscles, which require complex surgical interventions reserved for specialized centers.

4. The classification score of incisional hernias establishes the basis for the development of the IAH prediction score.

5. The interpretation of the sensitivity of classification score in incisional hernias and the adjustment of the composition parameters is dependent on the prediction of an increased IAP, this being the objective of another future analysis outside the doctoral study.

STUDY 2 - VALIDATION OF THE INTRA-ABDOMINAL PRESSURE MEASUREMENT METHOD

The aim of this study is to evaluate the usual methods of measuring IAP and to identify the optimal conditions for monitoring IAP.

Objectives of the study:

- Proposing a way to objectively compare the methods of monitoring IAP;
- Proposing a reproducible personal technique for intraoperative IAP measurement;
- Realization of the database for the evaluation of IAP measurement methods.

The identification of an optimal method of IAP monitoring for parietal surgery was carried out with the help of an observational, prospective, unicentric study, which compared three common methods of IAP monitoring with different degrees of difficulty in performance and costs. Current researches in the field of IAP have topic of interest difficulty in performance and costs [31]. A number of 90 patients were included (eligibility criteria for inclusion in the study being the diagnosis of acute cholecystitis for which elective laparoscopic cholecystectomy or delayed laparoscopic emergency surgery was performed).

Limitations of the study are determined by:

- Relatively small batch of patients;
- Lack of evaluation of existing commercial solutions – AbViser;
- Lack of validation in conditions of increased IAP to values greater than 12 mmHg.

Conclusions of the study were:

1. The notion of a Gold Standard enunciated by WSACS in the IAP monitoring technique is debatable and even in the presence of a consensus that has emerged since 2006, the dissemination of this information is still under development.

2. Among the methods of measuring IAP, the study showed that the Foley-manometer method is the most useful in continuous monitoring.

3. Given the existence of a range of error in any type of measurement, boundary values are difficult to highlight and subject to accuracy errors.

4. The monitoring methods of IAP are often far too complex, with many steps to follow and complicated gear, involve advanced technique, these aspects hindering the medical practice and their applicability.

5.Using our own manometry method, Foley-manometer, is a cost-effective method of monitoring, the initial investment in the digital manometer being reasonable, the rest of the consumables being available to any specialist.

6. For patients at risk of developing IAH, continuous monitoring of IAP is recommended, and more importantly, a patient with difficult incisional hernia, undergoing surgery to correct the abdominal wall defect, should have preoperative monitoring of IAP in order to determine a personal reference value.

7. Precise IAP monitoring is not easy to perform in non-specialized medical units, the instruments used in this sense being often unavailable.

8. The Foley-Manometer method is the most accessible method with the most accurate results in terms of cost-effectiveness.

STUDY 3 – ASSESSMENT OF THE IMPLICATIONS OF SURGICAL INTERVENTION ON INTRA-ABDOMINAL PRESSURE IN DIH

The purpose of the study was to assess the risk of developing abdominal compartment syndrome in patients with difficult incisional hernias, based on pre- and intraoperative data.

Objectives of the study were:

- Evaluation of risk factors for the occurrence of intra-abdominal hypertension syndrome;

- Elaboration of the patient evaluation score for the prevention of intra-abdominal compartment syndrome;
- Development of the algorithm for the selection of surgical techniques in order to prevent the occurrence of intra-abdominal compartment syndrome.

The research had the following characteristics: unicentric, within the Department of General and Emergency Surgery III, Bucharest Emergency University Hospital, prospective, between January 1, 2018 and December 31, 2021, non-interventional, descriptive and correlational.

The proposed study succeeds, through statistical significance, in generating a preoperative IAH/SCA prediction score in patients with incisional hernia, facilitating the choice of a suitable therapeutic option. It is easy to replicate, as it uses parameters available to specialists, and its predictive value has been shown to be high.

SCOR	0 pts	1pts
AGE	≤ 75	>75
ASA	≤1	>1
LAD	Nu	Da
MTD	≤15	>15

Limitations of the study are determined by:

- Heterogeneity of cases;
- Possible measurement errors considering that the method used may present reading errors;
- Lack of prospective validation of the patient evaluation score for the prevention of abdominal compartment syndrome;
- The lack of use of preoperative intra-abdominal hypertension prophylaxis methods in the surgical cure of hernias (chemical separation of the components of the abdominal wall - botulinum toxin, respiratory gymnastics exercises that increase the total lung capacity).
- Lack of a preoperative imaging evaluation protocol.

Conclusions drawn from the study were:

1. Out of a total of 238 patients, 49.2% developed various degrees of IAH, and 7.1% developed abdominal compartment syndrome.

2. Patients, in whom surgery was urgently indicated due to occlusive complications, presented a 5 times higher risk of developing ACS.

3. The risk factors for the occurrence of intra-abdominal hypertension syndrome were age over 75 years, ASA score > 1, loss of abdominal domain and MTD >15 cm.

4. The association of risk factors had a cumulative effect on the risk of developing compartment syndrome.

5. The combination of parietal augmentation techniques, respectively substitution is mandatory for patients who accumulate more than 2 risk factors.

6. The technique of augmentation by prosthetic substitution represented an element of prevention of SCA occurrence, none of the respective patients developing significant IAH. It should be noted that this technique is designed as an extreme solution that responds only to the vital need, leaving aside the other anatomical and functional considerations.

FUTURE DIRECTIONS OF RESEARCH

1. Multicentric prospective evaluation and validation of the elaborated scores.

2. Standardization of a measurement method specific to the pathology of the abdominal wall.

3. Realization of a complex DIH management algorithm focused on SCA prevention.

4. Proposing a classification of incisional hernias based on which the risk of SCA can be assessed.

5. Another direction of further research could be the identification of a complementary parameter to intra-abdominal pressure monitoring tools. Ideal, in order to measure intra-abdominal pressure, is the identification of an easily reproducible, more practical parameter.

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