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Incidence and prognosis of intraabdominal hypertension and abdominal compartment syndrome in children

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ABSTRACT

Purpose: Intraabdominal hypertension (IAH) and abdominal compartment syndrome (ACS) are associated with high mortality rates in children (40–60%). However, literature lacks comprehensive series in childhood. In this study, we aimed to determine the incidences of IAH and ACS, to identify high risk disorders for the development of IAH/ACS and to decrease ACS-associated mortality by early diagnosis and timely intervention.
Methods: A prospective study was performed between December 2009 and October 2010 in our institution. IAH was defined by a sustained or repeated pathological elevation in IAP ≥ 12 mmHg without a new organ failure. ACS was identified as a sustained IAP > 15 mmHg with a new organ dysfunction/failure. After recognition of IAH or ACS, patients underwent prompt decompressive interventions as medical or surgical procedures.
Results: 150 patients were enrolled to the study (86 M, 64 F). The incidences of IAH and ACS were 9% and 4%, respectively. High risk disorders were trauma, ileus, necrotizing enterocolitis, abdominal wall defects, diaphragmatic hernia and septic shock with massive fluid resuscitation. 14 patients with IAH were treated and mean IAP was decreased from 13.9 ± 1.9 mmHg to 9.2 ± 2.1 mmHg ($p < 0.001$). None of them progressed to ACS. Six patients with ACS underwent decompressive laparotomy. Mean IAP decreased significantly from 20 ± 3 mmHg to 9 ± 1.4 mmHg ($p = 0.001$). Vital signs like mean urine output, abdominal perfusion pressure (APP) and respiratory rate were significantly improved after surgery ($p < 0.05$). ACS-associated mortality rate was determined as 16%.
Conclusions: IAH or ACS was occurred in nearly one tenth of patients admitted to neonatal and pediatric intensive care units. High clinical suspect must be drawn on to recognize and treat these clinical complications more efficiently. Regular and frequent IAP measurement in high risk disorders is essential for early diagnosis. Lower mortality rates can be achieved by early recognition and timely intervention in children.

Abdominal compartment syndrome (ACS) is firstly described by Marey in 1863 as a constellation of the physiologic sequelae of increased intraabdominal pressure (IAP). In recent decades, this clinical entity is begun to recognize more frequently in childhood. The incidence of ACS is reported 0.6–4.7% in pediatric intensive care units [1–3]. Intraabdominal hypertension (IAH) is defined as the rising of intraabdominal pressure without any organ failure. IAH and ACS are the clinical stages of an ongoing pathological condition caused by increased intraabdominal pressure. ACS is a highly mortal clinical complication in children (40–60%) [1–3]. Despite its potential implications for all organ systems, it has been poorly appreciated in childhood. There are very limited prospective studies with large patient numbers [1,2,4]. Most of the reported studies are case presentations in children [5–7].

Increased IAP has deleterious effects on several organ systems with renal, pulmonary or hemodynamic compromise. Many of these detrimental consequences are reversible with timely and appropriate interventions. Unfortunately, patients are usually treated in an irreversible period of ACS. Early identification of patients who are prone to developing this syndrome is essential.

In this prospective study, we had three main goals; to determine the incidences of IAH and ACS; to identify high risk disorders for the development of IAH/ACS and to decrease ACS-associated mortality. Our treatment strategy depended on early diagnosis and timely decompressive intervention.

1. Materials and methods

A single center prospective study was performed in neonatal and pediatric intensive care units of our institution between December 2009 and October 2010. Ethical approval was provided from our institution's ethical committee. Patients stayed more than 24 hours at

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intensive care unit were enrolled to the study. All consecutive patients underwent at least one intraabdominal pressure measurement for screening. In clinically suspected patients for rising intraabdominal pressure, serial measurements were applied at 6 to 8 hour intervals. After recognition of IAH or ACS, patients underwent prompt decompressive interventions and measurements were kept on until this clinical condition resolved ultimately.

1.1. Intraabdominal pressure measurement technique

Intraabdominal pressure (IAP) can be measured by direct or indirect IAP measurement techniques. Direct IAP measurement from peritoneal cavity is invasive and not always possible in clinical practice. Indirect IAP measurement is noninvasive and can be applied from various intracorporeal cavities like stomach, rectum, uterus and bladder [8–12]. Over the years the indirect IAP estimation via the bladder evolved as the gold standard technique for the measurement of intraabdominal pressure [13]. The intrabladder pressure (IBP) must be measured as described before for standardization [9]. In our study, a modified classic manometric technique is preferred because of its simple applicability and low cost. The required equipments for measurement are a Foley catheter, 100 ml pressurized bag of isotonic sodium chloride solution with its infusion line, 10–20 ml syringe and ruler.

1.1.1. Method of measurement

Place patient at supine position. Clamp the Foley catheter distal to the sampling port. Disinfect the culture aspiration port of Foley catheter and insert syringe. Inject 1 ml/kg (max: 20 ml) saline from syringe into the bladder. Wait 30–60 seconds. Then insert the clamped infusion line of the pressurized saline bag to the culture aspiration port. Cut the infusion line from proximal part to the saline bag. Release the clamp to allow the drop of the saline in catheter. Wait until the saline level remains constant. Measure the constant saline level in catheter above symphysis pubis by ruler and convert cm H_2O to mmHg (1 mmHg = 1.36 cm H_2O).

Patients are diagnosed as intraabdominal hypertension (IAH) or abdominal compartment syndrome (ACS) according to the level of IAP values and organ dysfunction criteria.

1.2. The management of intraabdominal hypertension

IAH is defined by a sustained or repeated pathological elevation in IAP ≥ 12 mmHg without a new organ dysfunction/failure [13]. After diagnosis of IAH, patients underwent decompressive interventions and followed more closely with frequent and regular IAP measurements at 6–8 hour intervals (Fig. 1). Decompressive interventions for the management of IAH are medical precautions, IV diuretic administration after macromolecule infusion, ultrafiltration, paracentesis and decompressive laparotomy to treat the surgical cause of IAH like mechanical bowel obstruction. First of all, medical precautions were applied. These are correction of abdominal wall compliance by sedation or neuromuscular blockage and gastrointestinal evacuation maneuvers like nasogastric decompression or rectal enemas. If medical precautions failed to decrease IAP, other medical and minimal invasive treatment procedures are performed to evacuate extracellular fluid from intraabdominal cavity. The main goal is to treat this condition at IAH stage and prevent to progress to ACS.

1.3. The management of abdominal compartment syndrome

ACS is defined as a sustained IAP > 15 mmHg that is associated with new organ dysfunction/failure [13]. ACS = IAH + organ dysfunction.

The most common organ dysfunction/failure(s) are:

- Metabolic acidosis despite resuscitation
- Oliguria despite volume repletion
- Elevated peak airway pressures
- Hypercarbia refractory to increased ventilation
- Hypoxemia refractory to oxygen and PEEP
- Intracranial hypertension

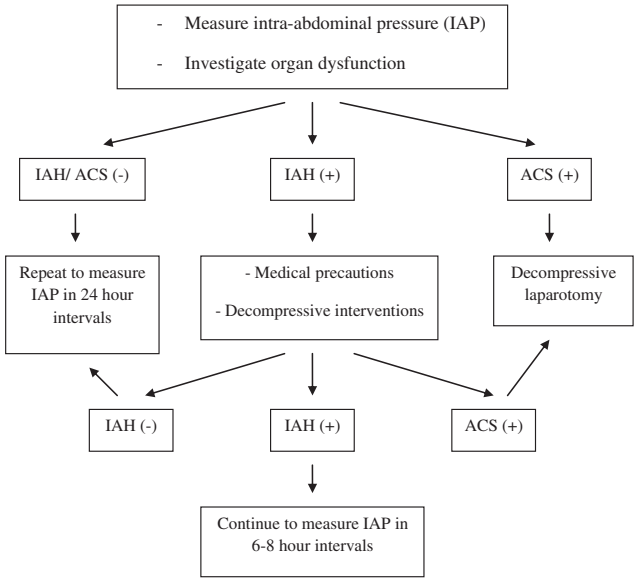

Fig. 1. The management algorithm in patients with high risk diseases for IAH/ACS.

After diagnosis of ACS, patients underwent decompressive laparotomy to treat the major cause of ACS. Various procedures like intestinal resection and adhesiolysis in mechanical bowel obstruction, bowel resection in NEC, splenectomy and blood evacuation in abdominal trauma were performed during decompressive laparotomy. If these interventions failed to decrease IAP, temporary abdominal closure or open abdomen procedures are planned as a last treatment strategy.

1.4. Statistical analysis

The statistical analysis is performed by SPSS for Windows 18.0. The high risk diagnostic groups for IAH/ACS are detected with Odd's ratios and confidence intervals by Logistical Regression Analysis. Categorical data are converted to crosstabs and underwent chi-square analysis. Repetitive measurements like before and after decompressive interventions are analyzed by variance analysis. We considered $p < 0.05$ to be statistically significant.

2. Results

A prospective observational study was performed on 150 consecutive patients between December 2009 and October 2010 (86 M, 64 F). Patients' mean age was 4.6 ± 5.4 years (1 day–18 years old) and mean weight was 16.6 ± 16.5 kg (680 g–78 kg). 34 of them were admitted to NICU and 116 to PICU. The incidences, high risk diagnostic groups and mortality rates after decompressive procedures for intraabdominal hypertension and abdominal compartment syndrome were reviewed.

2.1. The incidence of IAH and ACS

14 patients were identified as having IAH (9%). The incidence of ACS was 4% in six children. Totally, one tenth of patients admitted to intensive care unit were diagnosed as IAH or ACS (13%). There was not a significant difference in surgical or medical disorders to occur IAH/ACS ($p = 0.130$).