

Correlation between intra-abdominal hypertension and arterial lactate concentration in severe sepsis patients

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ABSTRACT

Intra-abdominal hypertension (IAH) in severe sepsis patients with consequent multiple organ failure is associated with increased arterial lactate levels. In this nonrandomized, prospective control trial, the correlation between intra-abdominal hypertension and arterial lactate concentration in severe sepsis patients was analysed.

Thirty-eight patients undergoing major abdominal surgery with confirmed severe sepsis constituted the severe sepsis patients group. Control group included thirty-eight patients undergoing elective abdominal surgery with at least two risk factors for IAH.

*Intra-abdominal pressure (IAP) was assessed in both groups every six hours during the first 72 hours, through a Foley catheter placed in the urinary bladder. IAH was diagnosed with two consecutive measurements of IAP > 12mmHg. At the same time lactate levels in arterial blood, SvO₂ and CVP were assessed. Data were compared using Student's *t* test. *P* < 0.05 was considered statistically significant. In the sepsis group, 25 patients (65.8%) had IAP > 12mmHg, 10 patients (26.3%) had IAP > 16mmHg and three patients (7.9%) had IAP > 20mmHg. In the control group, all patients had IAP up to 7mmHg. Arterial blood lactate levels were significantly increased in severe sepsis patients with IAP > 16mmHg (4,2mmol/L versus 1,2mmol/L, *P* < 0.05) compared to the control group. Mortality in severe sepsis patients with IAH was 24.5% (10 patients). Arterial blood lactate levels were significantly higher in severe sepsis patients IAH > 16mmHg compared to control group. Continuous IAP monitoring in severe sepsis patients is important for early detection of splanchnic hypoperfusion with consequent multi-organ failure, and for timely application of efficacious therapeutic procedures.*

Key words: intra-abdominal hypertension, arterial lactate concentration, sepsis

Introduction

Intra-abdominal pressure (IAP) is defined as a steady state pressure of the abdominal cavity. The prevalence of intra-abdominal hypertension (IAH) in severe sepsis patients ranges from 20-55%. IAH with consequent splanchnic hypoperfusion and multiple organ failure is associated with increased lactate levels in arterial blood. IAH was defined as a sustained or repeated pathological ele-

vation of intra-abdominal pressure (IAP) for >12mmHg and was graded into 4 levels – level 1: 12-15mmHg; level 2: 16-20mmHg; level 3: 21-25mmHg; level 4: >25mmHg. (1) Abdominal compartment syndrome (ACS) is defined as a sustained IAP >20mmHg with or without abdominal perfusion pressure (APP) <60mmHg, which is associated with new organ dysfunction. (2) IAH compresses mesenteric veins, which impairs venous flow from the intestine and causes intestinal oedema. Consequently, hypoperfusion, decreased intramucosal pH and bowel ischemia develops. (3, 4)

We are presenting the results of a prospective two-year non-randomised controlled trial conducted at the Department of Anaesthesiology, Reanimatology and Intensive Care at the University Hospital Centre in Zagreb. The correlation between intra-abdominal hypertension and arterial lactate concentration in severe sepsis patients was analysed.

Materials and methods

The study was a prospective non-randomized controlled trial, which included patients who underwent urgent major

Table 1. Risk factors for intra-abdominal hypertension

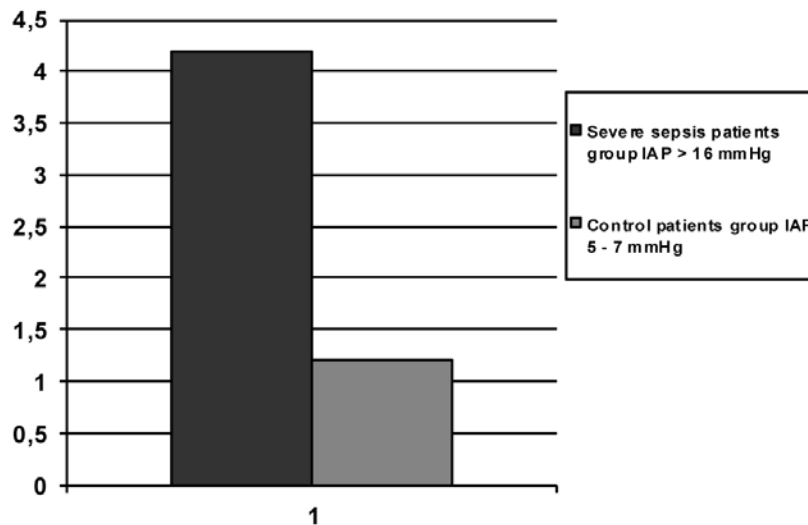
Factors
1 Obesity
2 Pancreatitis
3 Gastrointestinal bleeding
4 Liver dysfunction
5 Acidosis
6 Metabolic derangement/organ failure
7 Shock
8 Hypotension
9 Respiratory failure
10 ALI/ARDS
11 Fluid restitution (>3,5L crystalloid or colloid)

ALI, acute lung injury; ARDS, acute respiratory distress syndrome

abdominal surgery and were treated at the Department of Anaesthesiology, Reanimatology and Intensive Care at the University Hospital Centre in Zagreb, Croatia, between March 2010 and April 2012. A total number of 76 critically ill patients were divided into two groups. The severe sepsis patients group included 38 patients (22 male, age 45 ± 6 , APACHE II score 19 ± 4 and 16 female, age 42 ± 7 , APACHE II score 18 ± 2) who underwent major abdominal surgery and met standard international criteria for severe sepsis. (5-7) The control group included 38 patients (23 male, age 47 ± 6 , APACHE II score 18 ± 3 and 15 female, age 43 ± 5 , APACHE II score 17 ± 2) undergoing major abdominal surgery with at least two risk factors for IAH. Risk factors for IAH are presented in Table 1.

The exclusion criteria were: patients <18 years of age, pregnancy, allergy, patients with traumatic injuries to the urethra or the bladder, contraindication for femoral artery catheterisation, inability to obtain informed consent from patient and $BMI \geq 32 \text{ kg/m}^2$.

All patients were sedated with midazolam (0.05-0.15 mg/kg/h). Analgesia was maintained with sufentanyl (0.2-0.6 $\mu\text{g/kg}$). Vecuronium bromide (0.1 mg/kg) in intermittent dosing schedule was used



IAP, intra-abdominal pressure

Figure 1. Arterial blood lactate concentration in the severe sepsis patient group and the control group

for adequate muscular relaxation for two reasons: to eliminate spontaneous breathing and to decrease oxygen consumption. All patients were intubated and mechanically ventilated (Evita R XL, Dräger, Lubeck, Germany) using biphasic positive airway pressure (BIPAP) mode. Ventilator settings were: fractional inspired oxygen (FiO_2) 0.4-0.8; respiratory rate (RR) 12-18/min, P_{high} 15-25 cmH_2O , P_{low} 5-8 cmH_2O , T_{high} 2-5 seconds and T_{low} 0.5-1.0 seconds. Patients in both groups had PiCCO haemodynamic monitoring. Circulatory unstable patients had vasoactive pharmacological support (noradrenalin, 0.6-1.8 $\mu\text{g/kg/min}$) and their Sequential Organ Failure Assessment (SOFA) score was calculated.

IAP was assessed in both groups of patients every six hours during the first 72 hours through a Foley catheter placed in the urinary bladder with instillation volume of 50 ml of sterile 0.9% NaCl. IAP was measured at end-expiration in the complete supine position after ensuring that abdominal muscle contractions are absent and with the CVP scale zeroed at the level of symphysis pubis line and readings in cmH_2O were converted into mmHg by multiplication with 0.74. IAH was diagnosed with two consecutive measurements of IAP

>12 mmHg. At the same time lactate levels in arterial blood, SvO_2 and CVP were assessed. The presence of microorganism(s) in blood culture was verified as well. Data were compared using Student's t test and $p < 0.05$ was considered statistically significant.

Results

In the severe sepsis group 25 patients (65.8%) had IAP >12 mmHg, 10 patients (26.3%) had IAP >16 mmHg and three patients (7.9%) had IAP >20 mmHg. In the control group all patients had IAP up to 7 mmHg. Lactate levels in arterial blood were significantly increased in the severe sepsis patients group with IAP >16 mmHg (4.2 mmol/L versus 1.2 mmol/L; $p < 0.05$) compared to the control group (figure 1). Other haemodynamic parameters that were measured showed no statistically significant difference between the severe sepsis group and the control patients group (table 2). Generally, mortality in severe sepsis patients with IAH was 24.5% (10 patients).

Discussion

The primary objective of this study was to test the correlation between intra-abdominal hypertension and arterial lactate concentration in severe sepsis patients. As already described in

the Results section, there is a positive correlation between the two investigated indicators, which is in accordance with data from literature. Splanchnic ischemia detection in patients with IAH is also a problem when measures of global oxygen transport such as ScvO₂ and serum lactate are used in sepsis evaluation. In these patients IAP monitoring provides an earlier splanchnic hypoperfusion risk warning compared to mixed ScvO₂. (8)

In severe sepsis patients the important question is volume restitution in order to achieve haemodynamic stabilisation of patients with a diminished possibility of IAH development.

The question is what type of solutions should be preferred: crystalloid or colloid.

Reintam et al. noted that 45% of the severe sepsis population developed IAH. IAH presence was a marker for a higher mortality rate (50%) compared to sepsis patients who did not develop IAH (19%). (9) Sugre et al. showed that elevated IAP (>18mmHg) was an independent predictor of renal failure, ranking up with hypotension, age and sepsis in a large cohort of surgical ICU patients. (10)

Malbrain et al. found that even elevations of IAP >12mmHg in a mixed population of ICU patients were an independent risk factor for organ dysfunction and mortality (39% vs 22%). (11) Daugherty et al. noted that the majority of patients

Table 2. Other haemodynamic parameters measured in both groups

Variable	Severe sepsis patient group	Control group	p value
MAP (mmHg)	77.6±8.5	83.3±12.5	0.012
HR (bpm)	97.5±19.7	94.2±19.4	0.659
CI (l/min/m ²)	3.2±1.8	3.5±1.2	0.248
SVRI (dyn·s·cm ² ·m ²)	1180±391	1248±269	0.032
GEDVI (ml/m ²)	782±178	791±124	0.316
CVP (mmHg)	11±3	10±2	0.219
ScvO ₂ (%)	77±4	71±2	0.038

CI, cardiac index; CVP, central venous pressure; GEDVI, global end-diastolic volume index; HR, heart rate; MAP, mean arterial pressure; ScvO₂, central venous oxygen saturation; SVRI, systemic vascular resistance index

in their medical ICU population who developed IAH were patients with septic shock. Patients with IAH had a higher mortality rate (70% vs. 50%) and longer ICU length of stay (21 vs. 12 days). (12) A therapeutic approach, beside the conservative approach, includes surgical decompression when the intra-abdominal pressure is 20mmHg or greater, taking into consideration the potential benefits and the perioperative risk related to this procedure in each individual case.

Conclusion

Continuous IAP monitoring in severe sepsis patients is important for early detection of splanchnic hypoperfusion and consequent multi-organ failure as well as for the timely application of efficacious therapeutic procedures. Lactate levels in arterial blood were significantly higher in severe sepsis patients with IAH >16mmHg compared to control group patients without IAH. However, that measure is a late indicator of irreversible systemic hypoxia.

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