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## Assessment of the state of water sectors and central hemodynamics during restrictive protocol of perioperative infusion therapy in patients undergoing emergency laparotomy

**Abstract. Background.** Abdominal acute surgical pathology is an acute condition requiring emergency surgical intervention. The lack of objective instrumental-laboratory data on the patient's condition, the uncertainty in exact extent of surgical interventions, the difficulty of conducting a prognostic assessment are the factors that increase the risk of postoperative complications with high mortality rate (30–80 %). The purpose of the study was to evaluate the effectiveness of the restrictive protocol of perioperative infusion therapy in patients undergoing emergency laparotomy. **Materials and methods.** Having agreed with the local Ethics Committee and obtained the informed consents, 30 patients, who needed emergency laparotomy, were examined. Preoperative treatment was performed in the intensive care unit according to the Standards of professional protocols (the Ministry of Health of Ukraine, 2008): perioperative fluid management, prevention of thrombosis and wound infections. Hypovolemia was treated by infusion of balanced crystalloid solutions. The hypovolemia severity was determined by using the test of tissue hydrophilia by Shelestiuk and corresponded to the degree II. Infusion volume was 40–60 ml/kg/day. Thus, 25 % of the calculated amount of volume deficit were infused during the first hour of treatment. In the absence of hemodynamic effects of infusion volume, we administered the vasopressors (norepinephrine, phenylephrine) in accordance with general practices. The next 25 % were infused during two hours of treatment (including intraoperative period). Full restoration of volume deficit (last 50 %) was carried out by the end of the first day of treatment. After fluid volume was restored to the full and normovolemia (postoperatively) was achieved, infusion therapy was performed in accordance with general practices. We studied the clinical parameters of systemic hemodynamic, central and peripheral hemodynamic parameters and water sectors of the body. Scoring scales ASA and POSSUM were used for stratification of surgical risk. Control points were before surgery, days 1, 3, 5–7, 10–14, 28–30 after surgery. **Results.** The results of the study proved that acute surgical pathology in patients with moderate surgical risk is accompanied by the maintenance of a normal total volume of fluid with a significant redistribution of the water sectors of the body, such as plasma deficit with the development of hypovolemia, intracellular dehydration, the initial increase in the volume of the interstitial space. The change in water sectors is combined with the development of relative hyperdynamia due to an increase in the total peripheral resistance and heart rate. **Conclusions.** Acute surgical pathology in patients with moderate surgical risk is accompanied by the maintenance of a normal total volume of fluid with a significant redistribution of the water sectors of the body, particularly deficit of plasma with the development of hypovolemia, formation of intracellular dehydration, the initial increase in the volume of the interstitial space. The use of a restrictive strategy of infusion therapy in patients with moderate surgical risk allows restore the physiological volumes of the water sectors of the body and form a normodynamic type of circulation from the 3<sup>rd</sup> day of postoperative period.

**Keywords:** water sectors; central hemodynamics; restrictive protocol; perioperative infusion therapy; emergency laparotomy

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## Introduction

Abdominal acute surgical pathology is an acute condition requiring emergency surgical intervention. In this case, emergency laparotomy is the main method for both surgical diagnosis and surgical treatment in these patients. Emergency laparotomy is a great concept for more than 400 different types of surgical interventions and is about 53 % of the total number of surgeries. The complexity of providing high-quality medical care to patients of this category is associated with the heterogeneity of acute conditions, the need to assess the patient's condition and conduct preoperative preparation under the conditions of severe time limitation [1–3]. The lack of objective instrumental-laboratory data on the patient's condition, the uncertainty of the exact extent of surgical intervention, the difficulty of conducting a prognostic assessment are the factors that increase the risk of postoperative complications with high mortality rate (30–80 %) [4–6].

Such a high percentage of mortality and postoperative complications is associated with the development of multiple organ failure. Hypovolemia is one of the main causes of the development of multiple organ failure and occurs due to decreased drinking, vomiting, diarrhea, paralytic ileus, swelling and edema of the intestine. It forms violations of central hemodynamics, a deficiency of perfusion of the lungs, kidneys, and liver. These changes lead to hypotension, development of respiratory distress syndrome, hepatic and renal dysfunction, abdominal compartment syndrome. Analysis of evidence-based studies identified a priority effect of perioperative infusion therapy on the development of postoperative complications in patients with surgical pathology [3, 4].

The **purpose** of the study was to evaluate the effectiveness of the restrictive protocol of perioperative infusion therapy of a patient undergoing emergency laparotomy.

## Materials and methods

Having agreed with the local Ethics Committee and obtained the informed consents, 30 patients were examined. Acute case of emergency laparotomy included strangulated inguinal herniation (n = 6), strangulated ventral hernia (n = 1), acute intestinal obstruction (n = 10), perforated gastric ulcer (n = 8), perforated ulcer of the duodenum (n = 3), peritonitis (n = 2). We examined 16 men and 14 women of average age  $60 \pm 11$  years.

Inclusion criteria were the patient's age more than 45 years and less than 75 years; emergency laparotomy, predicted intraoperative blood loss less than 500 ml; A SA III; diabetes mellitus at the stage of compensation.

Exclusion criteria were the patient's age less than 45 years and more than 75 years; gastrointestinal bleeding; ASA I–II–IV, decompensated diabetes mellitus; pregnancy and lactation; allergic reactions to any component of drug therapy; patient's refusal to participate in the study. All patients were examined according to the protocol of the Ministry of Health of Ukraine No 297 (02.04.2010). At the same time, concomitant pathology was identified: diffuse diabetes mellitus type II in remis-

sion (n = 22), chronic bronchitis in remission (n = 14), excessive body weight (obesity I–II stage) (n = 12), community-acquired pneumonia (n = 4).

Preoperative treatment was performed in the intensive care unit according to the Standards of professional protocols (the Ministry of Health of Ukraine, 2008): perioperative fluid management, prevention of thrombosis and wound infections. Hypovolemia was treated by infusion of balanced crystalloid solutions. The hypovolemia severity was determined by using the test of tissue hydrophilia by Shelestiuk and corresponded to the degree II. Infusion volume was 40–60 ml/kg/day. Thus, 25 % of the calculated amount of volume deficit were infused during the first hour of treatment. In the absence of hemodynamic effects of infusion volume, we administered the vasopressors (norepinephrine, phenylephrine) in accordance with general practices. The next 25 % were infused during two hours of treatment (including intraoperative period). Full restoration of volume deficit (last 50 %) was carried out by the end of the first day of treatment. After fluid volume was restored to full and normovolemia (postoperatively) was achieved, infusion therapy was performed in accordance with general practices.

Surgical intervention was carried out under the total intravenous anesthesia. The average duration of the operation was  $60.6 \pm 20.3$  minutes.

We studied the clinical parameters of systemic hemodynamics: blood pressure, mean arterial pressure, heart rate (HR) and routine clinical laboratory tests (general blood and urine analysis, coagulogram, biochemical blood test). The central and peripheral hemodynamic parameters were assessed by the method of integral rheography with the apparatus Diamant: cardiac index (CI), general peripheral vascular resistance (GPVR). Such indicators of the body's water sectors as the volume of extracellular fluid (ECF), the volume of intracellular fluid (ICF), the total volume of fluid (TVF), plasma volume (PV) were studied by the method of noninvasive bioelectric integral evaluation of the body structure with the Diamant monitor complex.

Scoring scales ASA and POSSUM were used for stratification of surgical risk.

Postoperative complications were assessed according to the classification of Clavien-Dindo, 2009. Control points before surgery, days 1, 3, 5–7, 10–14, 28–30 after surgery.

The observation was conducted in accordance with the requirements of the Ethics Committee. Statistical processing of the results was carried out using the MS Excel 2007, Statistica 6 software package. The data are presented in the form  $M \pm m$ . Statistically significant values were  $p < 0.05$ .

## Results and discussion

An analysis showed an initial reduction of ICF and plasma volumes by 4 and 5 % below target, respectively, among patients undergoing emergency laparotomy before the infusion correction. It coincided with the degree II of dehydration and was accompanied by ECF increase by 6 %. The plasma volume was reduced by 4 % of nor-

mal. The general volume of liquid saved within the limits of norm. Relative hyperdynamia (CI exceeded normal values by 11 %) was supported by a vasospasm (GPVR was 6 % higher than normal) and tachycardia (HR was 12 % higher than normal). It maintained the blood pressure at the level of norm.

After preoperative infusion therapy with balanced crystalloid solutions of total volume of  $1733 \pm 340$  ml during 2 hours was performed, we noted a further increase in the incidence of heart failure to 9 % above normal, recovery of PV and ECF to normal against a background of exceeding the TVF of 2.5 % of normal. Restoration of volumes of water sectors was accompanied by stabilization of indices of central hemodynamics up to normodynamics with preserved moderate tachycardia (heart rate —  $96 \pm 6$  beats per 1 min).

On the 1<sup>st</sup> day of observation, the total infusion volume in patients amounted to  $4360 \text{ ml} \pm 450 \text{ ml}$ . The volumes of water sectors did not differ significantly from those at the end of the preoperative infusion preparation, we noted the formation of a normodynamic type of blood circulation (CI was 98 % of the norm), while GPVR was 2 % higher than normal and the blood pressure values were within the physiological norm. On the 3<sup>rd</sup> day of the postoperative period, the body's water sectors did not differ significantly from the norm values. It lasted until the end of the observation period. From 3<sup>rd</sup> to 14<sup>th</sup> days of treatment the parameters of central hemodynamics corresponded to the values of the norm, too.

## Conclusions

1. Acute surgical pathology in patients with moderate surgical risk is accompanied by the maintenance of a normal total volume of fluid with a significant redistribution of the body's water sectors:

- plasma deficit with the development of hypovolemia;
- formation of intracellular dehydration;
- the initial increase in the volume of the interstitial space.

2. The change in water sectors is combined with the development of relative hyperdynamia due to an increase in the total peripheral resistance and heart rate.

3. The use of a restrictive strategy of infusion therapy of patients with moderate surgical risk allows restore the physiological volumes of the body's water sectors and form a normodynamic type of circulation from the 3<sup>rd</sup> day of postoperative period.

**Conflicts of interests.** Authors declare no conflicts of interests that might be construed to influence the results or interpretation of their manuscript.

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### Оценка состояния водных секторов и центральной гемодинамики при рестриктивном протоколе периоперационной инфузионной терапии у пациентов с неотложной лапаротомией

**Резюме.** С целью оценки эффективности рестриктивного протокола периоперационной инфузионной терапии у пациентов с неотложной лапаротомией нами было обследовано 30 больных. Степень операционно-анестезиологического риска по шкале ASA соответствовала ПЕ, хирургического риска по шкале POSSUM — 1–5 % и совпала со средним хирургическим риском. Всем больным проведена предоперационная подготовка на протяжении 2 часов в условиях отделения интенсивной терапии в объеме  $1733 \pm 340$  мл, при расчетной суточной инфузионной нагрузке 40–60 мл/кг/сут. Больные были обследованы клинически, инструментально и лабораторно. В исследовании доказано, что острая хирургическая патология у пациентов со средним хирургическим риском сопро-

вождается исходным сохранением нормального общего объема жидкости на фоне дефицита объема плазмы с развитием гиповолемии, внутриклеточной дегидратации и интерстициального отека. Это формирует относительную гипердинамию за счет увеличения общего периферического сопротивления и частоты сердечных сокращений. Применение рестриктивной стратегии периоперационной инфузионной терапии позволяет восстановить физиологические объемы водных секторов организма и сформировать нормодинамический тип кровообращения с 3-х суток послеоперационного периода.

**Ключевые слова:** водные сектора; центральная гемодинамика; рестриктивный режим; периоперационная инфузионная терапия; ургентная лапаротомия

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### Оцінка стану водних секторів і центральної гемодинаміки при рестриктивному протоколі періопераційної інфузійної терапії в пацієнтів із невідкладною лапаротомією

**Резюме.** Із метою оцінки ефективності рестриктивного протоколу періопераційної інфузійної терапії в пацієнтів із невідкладною лапаротомією нами було обстежено 30 хворих. Ступінь операційно-анестезіологічного ризику за шкалою ASA відповідав ІІЕ, хірургічного ризику за шкалою POSSUM — 1–5 % і збігався з середнім хірургічним ризиком. Усім хворим проведена передопераційна підготовка упродовж 2 годин в умовах відділення інтенсивної терапії в обсязі  $1733 \pm 340$  мл при розрахунковому добовому інфузійному навантаженні 40–60 мл/кг/добу. Хворі були обстежені клінічно, інструментально й лабораторно. У дослідженні доведено, що гостра хірургічна патологія в пацієнтів із середнім хірургічним ризиком супроводжу-

ється початковим збереженням нормального загального об'єму рідини при формуванні дефіциту об'єму плазми та розвитком гіповолемії, внутрішньоклітинної дегідратації та інтерстиціального набряку. Це формує відносну гіпердинамію за рахунок збільшення загального периферичного опору судин і частоти серцевих скорочень. Застосування рестриктивної стратегії періопераційної інфузійної терапії дозволяє відновити фізіологічні об'єми водних секторів організму і сформувати нормодинамічний тип кровообігу з 3-ї доби післяопераційного періоду.

**Ключові слова:** водні сектори; центральна гемодинаміка; рестриктивний режим; періопераційна інфузійна терапія; ургентна лапаротомія