[illegible]

In no circumstances infusion therapy must be initiated with colloid administration!

e er! irst of all rehydration should be fulfilled hydra water If a patient suffers from deficiency of water first of all he she has to recei e water i e crystalloid solutions If the therapy is started with colloids then ad erse effects will be most li ely to emer e in a patient It means that de elopment of symptoms of acute renal insufficiency and arious coa ulation failures should be e pected in the postoperati eperiod halpa I et al

e t point or a more efficient attraction of fluids from the interstitial space it is reasonable to introduce heosorbilact into the infusion therapy program In this case a concept of a small olume infusion therapy which will be described below is implemented

And what about colloids? The up-to-date infusion therapy is based on the following approach: if the program of fluid support is intended for administration of more than 1 L of solutions, it should contain a colloid component. An ideal ratio of crystalloids and colloids is 3:1. So, depending on the clinical picture, for each 1–1.5 L of crystalloids there are 400 or 500 ml of colloids that should be transfused. From this perspective, we propose to include solutions of hydroxyethyl starches (HES)

Table 1. Indications for infusion therapy prior to performing emergency abdominal surgery (according to Park G., Row P., 2005)

Peritonitis > 24 hours or **Peritonitis < 24 hours and any 3 criterion out of the list:**	
Age > 65 years old	Hb < 100 g/L
Heart rate > 100 or < 30 beats per minute	Base deficit is less than 5 mmol/L
Respiratory rate < 10 or > 30 per minute	Prothrombin time is more than 25 sec
Diuresis < 20 ml/h within > 2 h	Leukocytosis is less than 2.0 • 10^9/L
Systolic arterial pressure < 100 mm Hg	Температура тела < 36,5 или ≥ 38,5 °C
SpO_2 < 90% in ambient air breathing	PaO_2 < 75 mm Hg in ambient air breathing
“Marbleness” and extremity coldness	Plasma potassium < 3 or > 5 mmol/L

(Gecoton or Gekodez) and/or gelatin solution (Volutenz) into the infusion therapy program. Find below detailed information on these solutions.

Infusion therapy targeted endpoints. When preparing a patient for an emergency surgery, it is helpful to have specific endpoints when we may say: "Yes, we have performed an adequate fluid therapy and patient is ready for the surgery". Such endpoints to be reached prior to emergency abdominal surgeries are represented in table 2.

As soon as the infusion therapy is completed, the surgery must be started immediately.

Intraoperative fluid therapy

Main tasks of the intraoperative infusion therapy are as follows:

— elimination of water deficiency developed prior to a surgery;

— replenishment of physiological fluid needs;

— replenishment of intraoperative pathological fluid losses.

And even when it comes to a planned surgery, certain fluid deficiency occurs in a patient by the beginning of the surgery. It is attributable to a traditional rule not to intake anything 4–6 hours prior to the operation. Moreover, in order to prepare intestines for the surgery, purgatives or enemas are often prescribed. Such arrangements lead to fluid and electrolyte losses, which are reasonable to be replenished with balanced crystalloid solutions, for example with Hartman's solution at a dose of 1.5 ml/kg/h.

It also should be taken into account that a surgical wound leads to tissue fluid losses and to sequestration. Such a deficiency manifests itself by reducing fluid volume in the interstitial and intravascular space. Approximate fluid volume to be infused for compensation of intraoperative fluid loss is specified in table 3.

The specified needs may be covered if the following infusion therapy scheme is kept. One litre of balanced electrolytic solution is administered during the first hour of the operation. Further, the infusion is performed at the rate of 300 ml/h; in case of a severe surgical wound the rate of infusion is increased up to 600 ml/h. The goal is to maintain the diuresis at the level > 0.5 ml/kg/h.

Peculiar complications may occur in major intraoperative bleedings. We reviewe this problem below.

Infusion-transfusion therapy of a massive operative bleeding

Massive operative bleeding (MOB) that accompanies the major surgeries is a specific critical state, pathogenesis of which is characterized by a severe persistent hypovolemia, anaemia and threatening coagulopathy in the combination with a vigorous shock-producing sympathoadrenal stress and release of inflammation mediators as well as with hypothermia (Gorobets E.S. et al., 2010).

On the one hand, such a blood loss happens during surgery, which is performed under anaesthesia and under constant control of a qualified anesthesiologist and with constant apparatus monitoring of main vital functions. It is obvious that a massive operative blood loss is to be easier to sustain by a patient than the loss of less volume of blood occurred outside the operating room. However, on the other hand, it is possible only in case of a proper structuring of the whole complex of anesthesia service, where adequate and rational infusion-transfusion therapy (ITT) plays the key role (Vorobyov A.I. et al., 2001).

Blood loss is an unavoidable component of surgical treatment. Provided that a surgeon has appropriate qualification, the volume of blood loss most often depends on the extensiveness and complexity of an operation. It is not only the necessity to remove damaged organs within healthy tissues but also a pathological angiogenesis capable to cause a pronounced vascularization of an operated

Table 2. Targeted endpoints of the infusion therapy to be reached before emergency abdominal surgery conduction

Extremity warming-up Herat rate < 120 per minute Normokalemia and normomagnesemia PaO_2 < 75 mm Hg in ambient air breathing	Systolic arterial pressure ± 10 % of normal value Diuresis > 1 ml/kg/h Hemoglobin > 90 g/L Lactate < 2 mmol/L or base deficit > -5 mmol/L

Table 3. Fluid volume to be infused for compensation of intraoperative fluid loss (Park G., Pow P., 2005)

Type of a surgery	Volume of fluid loss, ml/kg/h
Minor surgical trauma (for example, herniotomy)	3–4
Moderate surgical trauma (for example, cholecystectomy)	5–6
Severe surgical trauma (for example, bowel resection)	7–8

area that are often taken into account. These both factors may have a strong impact on the volume of blood loss (Gorobets E.S., Zotov A.V., Feoklistov P.I., 2011).

On the other side, application of the up-to-date surgical instruments having hemostatic properties (for example, ultrasonic, laser knives and so on), hemostatic sponges and bandages allows to decrease substantially the volume of blood loss. However, certain surgeries (particularly the major and nonstandard ones) are accompanied by massive bleedings requiring fulfillment of an active ITT.

Traditionally, a massive blood loss is construed as a loss of one VBC within 24 hours taking into account that the volume of blood circulation (VBC) amounts to 7% of an ideal body weight in adults and 8-9% in children. Alternative definitions also specify the following: loss of 50 % of VBC within 3 hours or loss of 150 ml per minute in 20 minutes (Stainsby D. et al., 2000).

According to E.S. Gorobets (2011), for proper analysis of the situation and adequate ITT conduction, the second specified criterion (loss of 50 % of VBC within three hours) is more practical as it allows to apply the approved algorithm of remedial measures.

It should be noted that the outcome of the massive blood loss depends on an individual tolerance of each patient to such a loss. Tolerance to blood loss includes a broad range of circumstances and conditions, such as age, gender, initial reserves of patient's vital functions, initial oxygen function of blood and the status of coagulation system, body temperature, type of anaesthesia and initial premedication preceding the surgery. The severity and length of the surgery are of great significance. Rapid loss of the same blood volume due to intraoperative injury of a large vessel (under the condition of proper actions fulfilled by the surgeon and anesthesiologist) is usually sustained better than a long bleeding during conduction of a prolonged traumatic surgery (Gorobets E.S., Zotov A.V., 2011).

Efficient ITT of a massive blood loss in the operation room is based on the following:

— maintenance of a sufficient heart preloading by means of intensive intravenous infusion;

— step-by-step manipulation with the infusion solution composition with the view both of already lost blood volume and of expected blood loss with due account taken of haemocoagulogram values;

— timely usage of cardiovasotonics (ephedrine, mesatonum, noradrenaline, dopamine) for maintenance of post- and preloading in cases of probable and developing haemodynamics crisis and hypovolemic shock;

— prevention and treatment of hemostasis system disorders (Gorobets E.S., Zotov A.V., 2001).

Considering the problem of MOB treatment, it is impossible to forget that bleeding occurs in an ill person, i.e. in a person suffering from these or those disorders that are associated both with the underlying disease and with concomitant pathologies that form a premorbid background of a developing bleeding. Moreover, a patient is operated under anaesthesia (which is often combined and multicomponent) that also has an impact on patient's state preceding the blood loss, mostly on haemodynamics and compensatory reactions.

Evaluation of a blood loss. In most cases only approximate evaluation of a blood loss volume is possible. It could be more or less precise if the major portion of outflowing blood is gotten into a suction unit. Weighing of blood-soaked drapes also helps. Attempts to calculate the blood loss volume by haematocrit level values, various tables and measurement gauges are both tempting and imprecise. And the most important thing, reliance on such evaluation techniques leads to under- and overdiagnosis of blood loss scope and serious errors in aid delivery tactics.

In intensive therapy of MOB, staging of the ITT, i.e. switch from infusion of crystalloids and synthetic colloids to timely and justified transfusion of blood components (fresh frozen plasma (FFP), packed red blood cells and donor platelets), plays a crucial role (table 4).

The principle of ITT staging in case of an ongoing bleeding allows an anesthesiologist to control continuing intravenous infusion maintaining the necessary VBC and not letting the excessive hemodilution to be developed with a loss of minimum acceptable coagulatory potential and oxygen delivery function of blood (Gorobets E.S., Zotov A.V., 2011).

It should be separately dwelt on the issue of emergency ITT of acute MOB accompanied by the rapid loss of a large amount of blood. In such a situation, the main task for a doctor who performs the infusion-transfusion therapy is to replenish the blood stream as quick and efficient as possible. Naturally, there is a question arises: which of the products does comply with these requirements the best, i.e. replenishes the VBC and maintains the haemodynamics parameters most effectively, promptly and safely?

Table 4. Step-by-step fulfillment of the infusion therapy in blood loss (according to Gorobets E.S., 2011, as amended)

Stages	Blood loss (% VBC)	Infusion composition
I	< 20	Crystalloids
II	20–40	Crystalloids + synthetic colloids
III	40–100	Crystalloids + HES + FFP + packed red blood cells
IV	> 100	Crystalloids + FFP + packed red blood cells + HES of II generation (6% solutions – up to 33 ml/kg, 10% solutions – up to 20 ml/kg) or HES of III generation (up to 50 ml/kg)

Application of hypertonic solutions of NaCl for treatment of a severe shock was proposed as far back as 1944. In 1980 I. Velasco released experimental data on resuscitation of dogs undergone simulation of a severe haemorrhagic shock. The study results remonstrated that even in presence of a blood loss amounted to 50% of VBC, infusion of 7.5 % sodium chloride solution at a dose of 4 ml/kg is sufficient for restoration of cardiac output and regional blood flow (Galushko O.A., 2011). At the same time there were published materials on the study of 12 patients with hypovolemic shock, who along with the conventional treatment received 100 – 400 ml of 7.5 % sodium chloride solution as intravenous 50 ml bolus infusions. In response to solution administration, they observed increase of arterial pressure, consciousness recovery and urine flow, i.e. there were observed signs of shock reversibility (Butrov A.V., Galenko S.V., 2008).

The above mentioned works gave an impulse to further studies and appearance of such a term as **small-volume resuscitation** meaning one of the methods of emergency therapy of different stages of shock and terminal states. This therapy based on a rapid small volume (4 ml/kg) infusion of 7.2–7.5 % sodium chloride solution is intended for quick mobilization of endogenous fluid into the blood stream from the interstitium and intracellular space via osmotic gradient. 250 ml of this solution exerts the same volemic effect as 1 L of 5 % albumin solution.

However, the haemodynamic effect of hypertonic solutions is of short duration, which is attributable to a rapid leveling of osmotic gradient between extracellular and intracellular spaces (Cherniy V.I., et al., 2012). In order to preserve the achieved increase of intravascular volume, they proposed to administer hypertonic solution of sodium chloride in combination with colloids. On the one hand, the obtained two-component solution contributes to an increase of plasma osmolarity and intracellular fluid mobilization (a hypertonic component), and on the other hand, it ensures plasma oncotic pressure increase and preservation of the intravascular volume (a colloid component).

As of today, it is assumed that the most stable volemic effect is exhibited upon administration of a mixture of hypertonic solution of NaCl and dextran or HES in the ratio 1: 1 at a dose of 4 – 5 ml/kg (Belyayev A.V., Bondar M.V., Dubov A.M. et al., 2004).

As such, we believe that usage of combined multicomponent solutions containing hypertonic solution of sodium chloride and HES solution is an interesting and promising concept. One of such solutions is Gecoton, a novel product of domestic manufacture.

Gecoton. The main active substances of the product are hydroxyethyl starch of III generation 130/0.4, xylitol and sodium lactate. Gecoton exhibits hemodynamic, rheological, anti-shock and detoxification effects.

Owing to its composition, Gecoton pertains to the group of multicomponent colloid-hyperosmolar solutions. After intravenous administration of the product, there is observed an increase of the blood osmotic pressure, intensification of fluid evacuation from tissues into the blood stream, restoration of the damaged haemodynamics, improvement of the microcirculation and rheological properties of blood, acceleration of cardiac function, enhancement of metabolic process and improvement of renal detoxification function.

The maximum daily dose (in exceptional cases, excessive doses are allowed) amounts to 20 ml/kg/day (1400 – 1600 ml/day). Usually, there is infused 5 – 10 ml/kg/day (400 – 800 ml/day).

Gelatin solutions, which have a modified molecular structure, deserve a special attention. They are synthesized from the denaturated protein. This protein is separated from collagenous tissues of bovine animals by thermal degradation, hydrolisis and succination. Gelatin products are isotonic, isooncotic (4–8 %) gelatin solutions and low-molecular (20000 - 40000 Da) plasma extenders. Their pH is 7.1–7.7, they produce colloid-osmotic pressure amounted to 33.3 mm Hg or 453 millimeter of water column, their osmolarity is 274 mOsm/l, and volume effect of such products amounts to 40–100 %.

Volutenz. Speaking about modern drug products of gelatin group, special mention should be made of Volutenz, a domestically produced drug preparation. Peculiarity of this product administration is that, from the toxicological point of view, it has no dose limitations. Maximum daily dose is based on the hemodilution degree. Special care should be taken in order to avoid reduction of hematocrit below critical values. Values, which are considered to be critical for a patient, are varied individually depending on capillary oxygen extraction, age of a patient, circulatory reserve and clinical state. In patients with normal oxygen needs and preserved compensatory mechanism, hemodilution with hemoglobin level of 8 g/100 ml or hematocrit level of 25% may be acceptable. In patients staying in the intensive care units, hemoglobin level must not be lower than 10 g/100 ml and hematocrit level – lower than 30 %. When necessary, additional blood and packed red blood cells transfusion is conducted. It also should be noted that prior to terminal surgical hemostasis, it is reasonable to plan ITT so that upon replenishing VBC deficiency hemodilution acceptable for a certain patient is developing. The point of blood dilution consists in an urge to minimize losses of blood corpuscles at the stage when a loss of a certain blood volume is inevitable. If hemodilution entails a clinically significant bleeding, then one can calculate upon lesser losses of blood corpuscles (in case of an equal volume loss) due to low hematocrit. If the situation allows, recovery of red blood cell values should be approximated after arrest of bleeding.

Need for fluids in the postoperative period

Several factors should be taken into account when drawing up the program of infusion therapy for patients in the postoperative period. Firstly, it is necessary to calculate a physiological need which amounts to about 25–30 ml/kg/day – about 2–2.5 l/day. Losses that are not perceptible (through skin and lungs) added to this number: 20 ml/h – 500 ml/day. In case of an increased body temperature in a patient, it is necessary to add 10 ml/h (250 ml/day) for each degree Celsius over 37 °C.

Specific losses and demand for fluids should also be taken into consideration. Thus, in case of enteroparesis, 20 ml/h (500 ml/day) should be added to the infusion program but only in the first 24 hours after surgery. 40 ml/h (1000 ml/day) should be added in case of losses into the third space after laparotomy and thoracotomy or in major tissue lesion but also only in the first 24 hours after surgery. Other losses are also restorable (through tubes, drainage etc.).

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ПЕРИОПЕРАЦІЙНА ІНФУЗІЙНА ТЕРАПІЯ

Резюме. У статті представлено погляд на сучасний стан проблеми проведення периопераційної інфузійної терапії. Велику увагу приділено вибору засобів для інфузійної підтримки в периопераційному періоді, складанню програм передопераційної підготовки, інтенсивної терапії масивної інтраопераційної крововтрати та післяопераційного ведення пацієнтів.

Ключові слова: периопераційний період, інфузійна терапія, крововтрата, кристалоїди, колоїди, гідроксиетильовані крохмалі, Гекодез, Гекотон, желатини, Волютенз.

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PERIOPERATIVE FLUID THERAPY

Summary. This article presents a view on the current state of the problem of carrying out perioperative fluid therapy. Much attention is paid to the choice of agents for infusion support in the perioperative period, creation of preoperative preparation programs, intensive care for massive intraoperative blood loss and postoperative management of patients.

Key words: perioperative period, fluid therapy, blood loss, crystalloids, colloids, hydroxyethyl starches, Gekodez, Gecoton, gelatins, Volutenz.