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CURRENT STATE OF THE PROBLEM OF LOCAL POSTINJECTIONALCOMPLICATIONS CAUSED BY CATHETERIZATION AND REPEATEDINTRAVENOUS INJECTIONS OF INFUSIONAL MEDIA(LITERATURE REVIEW)

abstract: At present, intensive therapy for critical conditions caused, in particular, by severe concomitant injuries and wounds, is impossible without adequate infusiontransfusion therapy, which includes providing vascular access and the use of a sufficiently large amount of infusions that differ in their physicochemical characteristics. solutions of medicines, the need for which for the patient may persist for several days, weeks or even months. In these conditions, the anesthesiologist-resuscitator is faced with the task of choosing an adequate vascular access and catheter that provide the introduction of the required volume of drug solutions per unit of time.

key words: infusion-transfusion therapy, local post-injection complications, peripheral vein catheterization, infusion media.

Medical causes of occlusion of systems for infusions and injections.

Currently, intensive care of critical conditions, caused, in particular, by severe concomitant injuries and wounds, is impossible without adequate infusion-transfusion therapy, which includes providing vascular access and the use of infusions of a sufficiently large amount of drug solutions that differ in their physicochemical characteristics, the need for which for the patient may persist for several days, weeks or even months [1,2,3,4,5].

In all situations, the central place in the treatment of victims is given to the restoration of the functions of vital organs and systems, one of the solutions of which is infusion-transfusion therapy. deficiency of circulating blood volume, elimination of tissue hypoperfusion during the first 24 hours allows to reduce the number of systemic complications in the form of a syndrome multiple organ failure, hospital infections "and increase the survival of patients with combined injuries in critical condition [6,7,8,9,10].

Under these conditions, the anesthesiologist-resuscitator is faced with the task of choosing an adequate vascular access and a catheter that ensures the introduction of the required volume of drug solutions per unit of time [11,12,13]. However, when providing assistance at the scene, for example, to a patient with traumatic shock, the choice of vascular access is primarily due to the possibility of establishing it as soon as possible in order to immediately start intravascular administration of “anti-shock” drugs, and not to increase the safety of prolonged intravascular injection and multiple intravenous injections. administration of drug solutions. Moreover, the injection method chosen under these conditions and the type of injector do not always guarantee the required infusion rate of drug solutions and most often differ from the choice

It is known that the maximum rate of intravenous infusion of drug solutions is determined not by the caliber of the vein chosen for catheterization, but by the size of the catheter and the viscosity of drug solutions flowing through it [18,19]. The fact is that the diameter of the catheter inserted into the vein is always smaller than the diameter of the vein, so only the catheter will determine the resistance to the flow of the injected fluid. It follows that the choice for central venous catheterization does not guarantee a higher infusion rate than for peripheral venous catheterization.

The effect of catheter size on the rate of infusion of solutions is determined based on the Hagen-Poiseuille equation. The equation establishes a direct dependence of the infusion rate (Q) on the pressure gradient along the tube (AP) and the radius of the catheter (r) to the fourth power, as well as an inverse dependence on the length of the catheter (L) and the viscosity of the solution (p.). This means that the volume of intravenously administered fluid will be less in long and narrow catheters, which explains the higher throughput of short catheters for peripheral veins, in contrast to long ones designed for catheterization of central veins [20]. And the volumetric flow rate of drug solutions with a lower viscosity coefficient, for example, a solution of 0.9% sodium chloride, will be higher than that of blood, the viscosity coefficient of which is 4 times higher than that of water.

Thus, the rate of infusion of solutions of drugs flowing through it.

However, in the case of repeated and multi-day administration of drug solutions through standard infusion devices and vascular catheters, the rate of administration of the same type of solutions gradually decreases. Therefore, even with an increase in fluid pressure in the system due to an increase in the height of the stand with a vial containing the injected solution, an increase in the installation time of the catheter progressively reduces its throughput in the flesh until the drugs enter the venous bed completely. It has been shown that a decrease in the rate of infusion
infusion solutions can be detected already on the 1st day of intensive treatment of patients [21,22,23] using various types and sizes of vascular catheters, installed according to standard methods and followed by their care according to the recommended rules [24,25,26].

Recently, in the departments of anesthesiology and intensive care, volumetric pumps (infusion pumps) and syringe infusion pumps (dispensers) have become widespread, allowing for infusion therapy, parenteral nutrition and drug administration with high accuracy and speed of intravascular administration of solutions [27,28,8,9]. For patients with combined trauma, the exact rate of continuous supply of a solution, in particular an adrenomimetic agent, becomes absolutely necessary, and its reduction, for example, in conditions of traumatic shock, can lead to complications and even death [29,30,31,32,33]. At the same time, quite often, when performing anesthesia and resuscitation in patients of this category, there is a need for simultaneous safe intravascular administration of solutions of various drugs at different rates, which is currently not possible without the use of these devices. In addition, modern models of infusomats and syringe pumps have timers that set the time of injection of the solution, automatic shutdown devices when the solution ends or air enters the system, and alarms when the occlusal pressure deviates from the specified parameters [34,35,36,37].

On the other hand, there are cases when the veins of some patients with combined trauma and catheters inserted into the veins were clogged with a thrombus already on the first day after vein puncture, despite the replacement of the infusion line and the use of “flushing” solutions with heparin or citrate [38]. In addition, through the installed catheter in this situation, it became impossible to draw blood into the syringe for laboratory tests, even when a sufficiently strong vacuum was created.

Consequently, long-term infusion-transfusion therapy and repeated administration of solutions with different physicochemical quality indicators through both conventional infusion devices and automatic devices is accompanied by a deterioration in their hydrodynamic characteristics. One of the reasons for this may be external compression of the catheter by a suture fixing it to the skin, as well as closing the outlet of the catheter tube due to its displacement in the lumen of the vessel by the venous wall or valve, as well as twisting of the catheter, for example, made of silicone in the lumen of the vessel. Since these causes are easily detected and quickly eliminated, and blockage of catheters still occurs, apparently there are a number of other causes of this complication. Another post-injection complication is a violation of the intravascular patency of the catheter itself, the probable cause of which may be mechanical obstacles caused by blockage of the catheter by a thrombus, the formation of sediment in its lumen when drug solutions are incompatible, and the formation of a biofilm on the inner surface of the catheter, which reduces its lumen [39,40] . This leads to a gradual narrowing of the catheter lumen and, as a result, to a decrease in the volumetric velocity of the "intracatheter flow" of drug solutions. As a result, replacement of the vascular access is required in order to continue intensive care, which reduces the quality of medical care for patients with concomitant trauma.

Thus, the causes of hydrodynamic disturbances in injectors with multiple and multi-day administration of drug solutions remain not fully understood. Remain undeveloped ways to control the patency of the vascular catheter in the clinical setting. Also, the possibilities of preventing intravascular and intracatheter occlusions remain not fully known.

Aggressive effect of vascular catheters on vein walls

Injections of drug solutions into liquid tissues remain the main parenteral routes of drug administration - into the body of patients during treatment in a clinical setting [41,42,43,44,45]. Injection administration makes it possible to achieve rapid penetration of drugs into the blood, their rapid distribution with the blood throughout the body, as well as a quick and pronounced effect of action, regardless of the general condition of the patient [46,47,48].

More often than other drugs, plasma substitutes are administered by injection, dehydrating, anesthetic, radiopaque drugs, solutions of antibiotics (penicillins and cephalosporins), local anesthetics, antihistamines, steroidal and non-steroidal anti-inflammatory drugs [8,9,49,50,51,52]. The chosen route of administration of drugs in critically ill patients caused by severe concomitant trauma is especially relevant, as it allows you to quickly and effectively eliminate dangerous disorders of vital organs and systems [53].

For this purpose, various types of vascular access and types of injectors are used in medical institutions, among which catheters are the most widely used for multi-day and repeated administration of drug solutions, which today are mainly represented by intravascular peripheral catheters intended for installation in the saphenous veins of the human body, in particular, the veins of the extremities [54] .

More than 500 million peripheral venous catheters are installed in the world in one year, and their use in practice has long been a common medical procedure

[55]. Such popularity of using peripheral intravenous catheters is due not only to the possibility of prolonged and repeated administration of drug solutions, but also to their rapid installation into a vein with minimal trauma to this procedure. In addition, high applicability is due to the reliability of access to the vascular bed, the possibility of obtaining biochemical and hemodynamic information, the availability of mastering the technology of catheterization by paramedical personnel [56,57,58,59].

Currently, the market for medical products is filled with a large range of peripheral vascular catheters manufactured by companies in many countries around the world. Among them are such large manufacturers of medical products as B. Braun, Helm Pharmaceuticals, Becton Dickinson, Terumo and others [60,61].

Depending on their purpose, catheters are divided into hagiographic, used for the introduction or infusion of contrast agents and / or liquids, as well as for measuring pressure and blood sampling; central venous catheters used to introduce or remove fluid from a central venous system, and/or to measure pressure in an artery or vein to dilate part or parts of the vascular system; peripheral catheters with an internal needle, placed for the introduction (or removal) of fluids or devices into (or out of) the peripheral vascular system.

At the same time, in the conditions of departments of anesthesiology and resuscitation, surgery, operating rooms, several types of vascular catheters can be used simultaneously to provide specialized medical care to patients with severe concomitant injury. However, in critically ill patients, peripheral vascular catheters are the leading injectors [62,63,64].

Considering a wide range of types, sizes of peripheral vascular catheters, materials from which they are made, a variety of saphenous veins of patients and indications for catheterization, the main rules for choosing veins and catheters, as well as the sequence of stages of vascular catheterization, have now been formulated [65,21]. It has been determined that the catheter should cause the least discomfort to the patient, providing an optimal infusion rate, good dilution of the injected drug with blood, since the administration of drugs with a pronounced irritant effect on the vessel requires, respectively, the use of large veins and good blood flow. Smaller diameter catheters allow better blood flow around the catheter and dilution of the drug with blood [66,67].

There are suggestions that the length of the catheter should correspond to the length of the straight section of the vein used, and its diameter should correspond to the diameter of the selected vein due to the fact that large diameter catheters can close the lumen of the vein or damage its inner lining [68]. However, to date, no company produces catheters with a wound length that allows you to choose a catheter with an accuracy of up to 1 mm. For catheterization, first choose large, well-visualized distal veins on a non-working arm, soft and elastic to the touch, with a straight section corresponding to the length of the catheter, avoiding injection in the area of the flexor surface of the joints, close proximity to arteries or their projections, as well as previously catheterized veins and veins of the lower extremities [24,69].

Catheterization of the saphenous veins of the extremities should include a medical prescription in the medical history, preparation of the patient for the catheterization procedure, selection of the saphenous vein for subsequent injection, hygienic treatment of the hands of the medical worker performing the procedure and the area of catheterization using detergents and antiseptics, placement of the catheter according to general rules, closing it with a connecting device with a heparinized solution, an obturator or connecting it to an infusion system pre-filled with an infusion solution, fixing it to the skin with aseptic material [70,71,72].

However, despite the fact that peripheral vein catheterization is a significantly less dangerous procedure than central venous catheterization, it also threatens with complications. The most common complications include phlebitis, thrombosis, catheter occlusion, embolism, hematoma, and perforation of the venous wall [66].

Today, a significant proportion of physicians who use peripheral vascular catheterization to infuse drug solutions in the emergency care of critically ill patients most often retain the desire to achieve a systemic effect of administered drugs without taking into account the local safety of the vascular catheters themselves [38]. Information provided by the manufacturer in accordance with the requirements of GOST, includes a description of the catheter, outer diameter, effective length, name or trade mark and address of the manufacturer, batch designation catheters, date of manufacture and expiration date, storage conditions and storage instructions, sterility designation, method of sterilization, single use designation, any known chemical or physical incompatibilities with catheter contact materials, instructions for use and safety, flow rate for each channel and color code. At the same time, there is no information about the effect of the material from which the catheter tube is made on the endothelium after its intravascular location due to subcutaneous catheterization.

Meanwhile, it is known that one of the factors that increase the likelihood of post-injection complications may be inadequate catheter material due to its special physicochemical characteristics [73].

Currently, the following materials are used for the production of vascular peripheral catheters: silicone, teflon, polytetrafluoroethylene, polyurethane and its modification - vialon.

It is believed that the best materials for the manufacture of catheters are polyurethane and silicone. There is an opinion that Teflon and polyvinyl chloride are somewhat inferior to them, and polyethylene catheters have the worst properties [60,63,74]. At the same time, the comparative characteristics of materials are based on such indicators as the coefficient of surface friction, resistance to bending or flexibility. For example, Teflon cannulas have a low coefficient of surface friction, which ensures a quick and painless puncture. However, at the same time, they are extremely unstable in bending, which can lead to a fracture of the cannula with its fragmentation with several repeated bends. This can occur in the case of catheterization of the saphenous vein, in the area of the "working" joint during flexion and extension movements of the unfixed limb, as well as during manipulations [61,75].

Recently, much attention has been paid to the thermoplastic properties of the material for the catheter tube, which change their physical properties depending on the temperature of its environment [3,4,25]. So polyurethane being a very soft, thermoplastic material, the most gently interacts with the endothelium of the vein, thus minimizing the risk of developing mechanical phlebitis. However, if the ambient temperature approaches body temperature, for example in hot climates, the softness of the polyurethane catheter may prevent its comfortable insertion due to the "wrinkling" of the catheter tube during its passage through the soft tissues of the skin and subcutaneous fat. To prevent this problem, all manufacturers producing vascular catheters from this material and delivering to countries with a hot climate, it is recommended to place it in a refrigerator for several minutes before catheterization: the material will become hard upon cooling, and after installation it will acquire the necessary softness [13].

Soft and flexible catheters made of silicone have a slippery surface due to low surface tension, are thromboresistant, but can become tangled inside the vessel, change shape with increasing pressure, up to rupture.

The surface of tubes of peripheral venous catheters, made of different materials, determines not only their elasticity and degree of thrombogenicity, but also the resistance of catheters to infection. Thus, the "lumpy" polyethylene tube of the catheter creates a slowdown and turbulence of the blood flow and promotes the formation of a fibrin film, to which microorganisms adhere [76]. An in vitro study demonstrates that catheters made from PVC or polyethylene are less resistant to microbial adherence than catheters made from Teflon, silicone, or polyurethane [77]. Thus, catheter materials having surface defects increase the adhesion of some microbial species, for example, coagulase-negative staphylococcus aureus, Acinetobacter calcoaceticus, and Pseudomonas aeruginosa; catheters made from these materials,

In addition, the adhesion properties of the microorganism are also important in the pathogenesis of catheter-associated infection, for example, S. aureus can be firmly fixed to various proteins (e.g., fibronectin) commonly found on catheters, and coagulase-negative staphylococcus aureus is firmly fixed to polymer surfaces to a greater extent than others. infectious agents (eg Escherichia coli or S. aureus).[78].

Therefore, in the manufacture of modern vascular catheters, it is Teflon, polyurethane and silicone that are used, which have less aggressive properties in relation to the vascular wall and flowing blood. Nevertheless, it should be noted that almost all manufacturers of peripheral vascular catheters in the instructions for use indicate the need to remove catheters inserted into the vein 72 hours after catheterization, suggesting the occurrence of complications regardless of the material of manufacture of the catheter.

It is believed that an increase in the time the catheter is in the vein over the specified period is accompanied by an increase in the number of complications, in particular phlebitis and thrombosis, without determining the real cause of their occurrence in most cases. Although there are studies that have shown that the catheter can be in the saphenous vein for more than 72 hours without signs of inflammation [79,80].

Also, methods for monitoring the local safety and toxicity of vascular catheters have not been developed [81]. The possibilities of improving the safety of saphenous vein catheterization methods and methods of improving the safety of multiple drug injections remain unknown [43,44,45,42].

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