

## АНАЛІТИЧНІ ОГЛЯДИ / ANALYTICAL REVIEWS

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MANAGEMENT TACTICS FOR BLEEDING  
IN CHILDREN WITH MILITARY TRAUMA:  
LITERATURE DATA

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**Summary.** *The civilian population always suffers during hostilities. There are modern protocols for emergency medical care for military trauma in adults. However, for children, there are no approved guidelines, especially for the management of bleeding. Trauma is the leading cause of death between the ages of 1 and 19, with blood loss accounting for 40% of all deaths from injury. Regarding the causes of death during the war, bleeding accounted for 80%. Limb circumference in children is usually much smaller than in adults, which calls into question the ability of a standard turnstile to effectively stop bleeding in a child. Many turnstiles have a rigidly fixed mechanical clamping system (such as a windlass or ratchet), which eliminates their effectiveness in applying to the limb with a circumference less than expected. Also, the pressure of the mechanical windlass system for children can be excessive and lead to complications. However, there is reliable data on the effective classic application of the tactical turnstile CAT in children aged 1 year with a circumference of the limb of at least 13 cm and can be used by a medical professional of any qualification. It is allowed to use the CAT turnstile in children from 3 months of age, but the application technique requires modification and experience of a medical professional. When stopping bleeding, children under 2 years of age are recommended to start with direct pressure on the wound, and only if ineffective or impossible pressure to apply a tourniquet to the limb above the wound, or tamponade the wound with nodular bleeding. However, in any case, in the presence of massive bleeding from the limb or amputation of the limb, the primary method of stopping bleeding is currently the imposition of a tactical turnstile CAT.*

**Key words:** *Children; Bleeding; Military Trauma; Turnstile.*

The civilians always can struggle during the acts of warfare. The horror of the war, unfortunately, has not escaped Ukraine and there are already huge losses among civilians, including children. With the help of medical staff, the victims are being evacuated from the center of hostilities in the hospital. There are modern protocols for providing emergency medical care for military injuries in adults. However, for children, there are no approved guidelines, especially for the management of bleeding. Trauma is the leading cause of death between the ages of 1 and 19, with blood loss accounting for 40% of all deaths from injuries [1]. Regarding the causes of death during the war, bleeding accounts for 80% [2]. Bleeding due to military injury occurs mainly due to traumatic amputation of limbs or due to a mine blast injury with damage of large vessels. So-called nodular bleeding is possible when the injuries are localized in the neck, armpits, groin, perineum and buttocks. Therefore, we have analyzed foreign publications over the past 10 years on the optimal way to temporarily stop bleeding in children due to injuries during hostilities.

Modern types of turnstiles have been tested on persons  $\geq 18$  years of age and are successfully used in the army. The proper function of the turnstile depends on its ability to tighten and provide sufficient circular pressure to stop distal blood flow. This usually involves applying a strap and then tightening with a mechanism that provides maximum pressure on the limb. Limb circumference in children is usually much smaller than in adults, which calls into question

the ability of a standard turnstile to effectively stop bleeding in a child [3]. Many turnstiles have a rigidly fixed mechanical clamping system (such as a windlass or ratchet), which eliminates the effectiveness of their application to the limb with a circumference less than expected. Also, the pressure of the mechanical system of the windlass for children can be excessive and lead to complications [4, 5]. However, military research suggests that standard tactical turnstiles can be used to stop bleeding in children to save lives [6, 7].

According to data published in 2019 in the United States, mine injuries were the most common reason for hospitalization of children in military hospitals during the recent wars in the Middle East. The study involved 1,004 children, of whom 911 were assisted by standard means - stopping bleeding by applying a Combat Application Tourniquet (CAT), providing intraosseous access, infusion therapy and analgesia. 93 children were assisted by improvised means - applying other types of harnesses, improvised turnstiles, providing intravenous access. The results of the study indicate that the survival rate among groups of children was 88.1% and 89.2%, respectively [8].

Classic CAT turnstiles are recommended for temporary stop of massive bleeding from the extremities in adults, but their use in children requires further study. There are also discussions about the best turnstile design for children of different ages [9]. Two studies were conducted in 2019-2020, which involved 73 children aged 2 to 16 years. The first study involved 60 children aged 6 to 16 years who

had a CAT-7 windlass tourniquet placed on an intact upper limb and tested for peripheral pulsation below the tourniquet site by Doppler imaging [10]. The second study involved 13 children aged 2 to 7 years, who applied a turnstile CAT-7 on the lower extremity, followed by Doppler ultrasound examination [11]. Both studies have shown that windlass tourniquets are able to completely eliminate the distal pulse on the limb in 2 years old children with a limb circumference of at least 13 cm [12, 13]. However, both studies did not compare different types of turnstiles and harnesses to assess best performance. It is also likely that other types of windlass turnstiles may not provide successful tightening around the limb with a small circumference.

A group of 13 children aged 1 to 8 was recruited to determine the minimum age for the effective use of the CAT turnstile. Indicators such as weight, height, blood pressure and arm and leg contours were determined. Under general anesthesia, a tourniquet was applied to the limb. Doppler imaging was used to assess blood circulation in the limb before and after the tourniquet application. The minimum circumference of the limb was 13 cm. In all children, the tourniquet was 100% successful [11].

The effectiveness of ratchet turnstiles in children has not been proven. The presented results of experimental studies on models with a small limb circumference indicate the lack of success in the use of turnstiles with a rigidly fixed mechanical clamping system [14, 15].

There are no clinical data on the effective use of standard or improvised turnstiles in children aged before two years, including newborns. An experiment was conducted, during which CAT turnstiles were superimposed on the model of limbs corresponding to the size of the limbs of a 3-5 months old child. When applying a turnstile to the limb with a 13 cm circumference, the overlay technique was classic. When applying 8 cm to the limb, a modification of the technique was required, which consisted in wrapping the tape in the form of the number 8 around the windlass. The most difficult was the application of the turnstile on the extremities with a circumference of less than 13 cm, as this requires a change in the technique of using the turnstile and more time to apply [15]. However, in the conclusions, the use of the tactical turnstile CAT in children over 3 months of age is still considered appropriate because of the ease of use by a medical professional of any profile, with a slight modification of the application technique. Also in newborns and children under 2 years of age, the method of stopping bleeding by

direct pressure on the wound is more effective than in older children and adults [16]. Thus, a clinical case is described when a traumatic amputation of a limb in a 14-month-old child occurred as a result of a traffic accident. The nurse imposed a tactical turnstile CAT, which effectively stopped the bleeding and saved the child's life [17].

It is considered permissible to use in children hemostatic bandages and tamponade of life-threatening nodular bleeding. Although there are no clinical trials in children, data on adults suggest the effectiveness of the above methods [13].

The Pediatric Trauma Society and the Tactical Emergency Committee recommend the use of the CAT tactical turnstile in pre-hospital children to temporarily stop bleeding [18, 19]. The Children's Trauma Association recommends the use of turnstiles in children with bleeding from the extremities if direct pressure on the wound is not effective, or if the attempt of direct pressure is too resource-intensive [18]. The Pediatric Working Group of the Tactical Emergency Committee recommends the use of turnstiles for life-threatening bleeding from the extremities in children as a priority method for both direct threat (assistance in the red zone under fire) and indirect threat [19].

In conclusion, we can say that in the literature there is very little data on methods of temporary stop of bleeding in children at the pre-hospital stage. There are no recommendations for tactical medicine for children. Therefore, it is important to conduct research on the effectiveness of existing methods and the development of new means of temporary cessation of bleeding in children, especially aged before 2 years. However, there is reliable data on the effective classic application of the tactical turnstile CAT in 1 year-old children with a circumference of the limb of at least 13 cm and can be used by a medical professional of any qualification. It is allowed to use the CAT turnstile in children from 3 months of age, but the application technique requires modification and experience of a medical professional. In children under the age of 2 years, to stop bleeding that is recommended to start with direct pressure on the wound, and only if it is ineffective or impossible – to apply a tourniquet to the limb above the wound, or to tamponade the wound with nodular bleeding. However, in any case, in the presence of massive bleeding from the limb or amputation of the limb, the primary method of stopping bleeding is currently the application of a tactical turnstile CAT.

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## ТАКТИКА ЗУПИНКИ КРОВОТЕЧ У ДІТЕЙ З ВІЙСЬКОВОЮ ТРАВМОЮ: АНАЛІЗ ЛІТЕРАТУРНИХ ДЖЕРЕЛ

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### Резюме

**Вступ.** Під час бойових дій завжди страждає цивільне населення. Є сучасні протоколи надання екстреної медичної допомоги при військовій травмі у дорослих. Проте щодо дитячого віку – немає затверджених рекомендацій, особливо стосовно менеджменту кровотеч. Травма є основною причиною смертності у віці від 1 до 19 років, причому кровотрата становить 40 % усіх причин смертей від травм. Стосовно причин смертності населення під час війни, то на кровотечі припадає 80 %. Окружність кінцівок у дітей, як правило, набагато менша, ніж у дорослих, що ставить під сумнів здатність стандартного турнікету ефективно зупинити кровотечу у дитини. Багато турнікетів мають жорстко фіксовану механічну систему затискування (наприклад, брашпиль або трешотка), що виключає їх ефективність накладання на кінцівку з округлістю, меншою за передбачену. Також тиск механічної системи брашпилью для дітей може бути надмірним і призводити до ускладнень. Проте є достовірні дані стосовно ефективного класичного накладання тактичного турнікету «CAT» у дітей віком від 1 року з обводом кінцівки не менше 13 см і може бути застосоване медичним працівником будь-якої кваліфікації. Допускається застосування турнікету «CAT» у дітей віком від 3 місяців, проте техніка накладання потребує модифікації та наявності досвіду у медичного працівника. При зупинці кровотечі дітям молодше 2 років рекомендується починати з прямого тиску на рану і тільки за не-ефективності або неможливості тиску застосовувати турнікет на кінцівку вище місця поранення, або проводити тампонаду рани при вузлових кровотечах. Проте в будь-якому випадку при наявності масивної кровотечі з кінцівки або при ампутації кінцівки першочерговим методом зупинки кровотечі на даний час вважається накладання тактичного турнікету «CAT».

**Ключові слова:** діти; кровотечі; військова травма; турнікет.

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