Damage control is a term used in a U.S navy during the Second World War. It meant the repair of a damaged ship so as it could continue its mission or at least reach the nearest port. In medicine, taking an accident victim in a critical state into consideration, this definition would apply to procedures for pre-mastering the greatest threats so that the patient can survive the next few to several hours in a ‘safe port’ – an intensive care unit. The time spent there should be used to complete the diagnosis, complement the volume of the vascular bed, level electrolyte and acid-base disorders, fight hypothermia, collect the necessary blood and prepare a definitive plan of conducting operations, what, at the optimistic version, ultimately creates opportunities to save victims’ lives. The immediate, comprehensive and definitive seeing to various defects which requires some time and is associated with further damage, such as massive blood transfusion, hypothermia while the patient is on the operating table, and finally, further destruction of tissue, could lead to a progressive deterioration of the patient’s condition and ultimately to his death in a shorter or longer time.

In seeking the origins of such a procedure, we find them in the days of ancient Egypt, the Middle East and pre-Columbian America, where in critical situations trepanation of cranium was performed – probably with some success on occasions (1). In modern times, damage control could be observed during the Napoleonic wars, when emergency amputation of crushed limbs was carried out in close proximity to the battlefield. It saved many lives and played a similar role to sulphonamides and penicillin which 150 years later were used in the battlefields of World War II. The creator of this military „emergency medicine” in the Napoleonic armies was Dominique Larrey, and Rafał Czerwiakowski (2) became his Polish counterpart. In a sense, in its initial version, a surgery inaugurated by Küntscher in 1939 – the intramedullar nailing of bone fractures – was also such kind of medicine.

In the 1950s so called emergency thoracotomy appeared. It was performed in pre-hospitalisation period for a better, as it seemed, direct cardiac massage, however, the method was abandoned later.

“Triad of death” – acidosis, coagulopathy and hypothermia – is a threat to all accident victims with a heavy bleeding. In this context, a ‘golden hour’ ends when these disorders are stopped during an abbreviated operation and while the patient is still alive. The essence of a damage control concept is to perform the smallest possible surgery while an immediate and temporary dealing with life threatening condition which mainly stems from haemorrhage, and also in the critical state of the dying patient with profound disturbances of homeostasis, for whom the same treatment additionally enhances any disorders.

In this type of action we can also include emergency department thoracotomy sometimes performed during a pre-hospitalisation period, and a number of other shortened procedures, i.e. abbreviated craniotomy, abbreviated thoracotomy, abbreviated laparotomy, staged laparotomy to cease a massive haemorrhage. For the same group of treatment certain orthopaedic procedures can be added (external
pelvic stabilization to reduce the haemorrhage to retroperitoneal space, or external operational stability of long bone stems fractures, in order to avoid secondary complications: early – local and remote – the whole body. The concept of damage control involves a procedure of ensuring the flow of blood in damaged limbs. It is done by immediate placing bypasses as an alternative of a ligation of a damaged artery in patients with a prognosis that their limbs will not be amputated. Embolisation and bypasses of damaged large blood vessels are also done.

In each of these cases, therefore, initially, in the first stage, a minimized, abbreviated emergency procedure is performed, which can sometimes prove to be definitive, as in the stabilization of the outer bone fractures. Then, in the second stage, the patient is treated intensively to avoid concussion and is diagnosed. If his condition stabilizes after twelve or twenty hours, he is taken to the operating room again, where, in the third stage a complete treatment to all damage is performed.

Abbreviated craniothomy

Despite better diagnostic imaging methods and the possibility of continuous monitoring of intracranial pressure and blood flow through the brain, mortality after severe injuries still remains at a very high level, e.g. in the U.S. it goes up to 33% and in Poland it is even higher. In the U.S., further 80 to 90 thousand patients a year survive with a smaller or greater degree of permanent disability (3). The reason for this is not only the destruction which is a direct consequence of the injury, but, equally, the effects of expanding the intracranial compartment syndrome after a rapidly growing oedema and secondary brain damage. Current typical operations, including the evacuation of haematomas or the immediate removal of damaged tissue, in some of the most serious cases, do not deliver the expected results. The concepts of conservative treatment also turn out to be ineffective, from high-doses of steroids and diuretic drugs, through oxygen therapy, barbiturates coma, etc., to neuroprotective medications. Unfortunately, the model for application of hypothermia in the above mentioned cases has not been created. In this situation an operation involving the removal of the skull, opening the endocranium, the evacuation of large haematomas and covering the loss of biological membranes with a loosely fixed transplant of biological membrane biofilm, e.g. bovine pericarditis is suggested as an initial and life-saving action. It is a less destructive, safe and simple procedure, performed in a critical situation. An objective assessment of this procedure can not be conducted due to a small number of patients who undergo such an operation (4, 5, 6).

Abbreviated thoracothomy

Emergency department thoracotomy (EDT), has been out again in the center of interest. It was originally proposed as an ultimum refugium to perform the immediate closure of the wound on heart with a heavy bleeding, before the patient arrives to the operating room. Currently EDT is still recommended only (also in ATLS standards) for closures of stab wounds in heart with a heavy bleeding (7) (a patient rarely survives with gunshot wounds). Here, survival reaches 27% and increases in reverse depending on the time needed to complete thoracotomy, especially when there is a current electrocardiographic curve available when you admit a patient to the EDT. It should be emphasized that this procedure, however, should really be reserved for the most serious cases as it is fraught with many complications. When carried out outside the operating room it exposes the medical personnel not only to legal responsibility, but, like in the case of patients, to an infection. Similarly to emergency craniotomy, a discussion on the subject remains open (8-12).

Apart from emergency thoracotomy, in the chest, pleural cavity packing can be performed to stop haemorrhage and a large air leak. Non-anatomic lung resection or dressing of larger damaged vessels, and simple pulmonary pulp stitching are also recommended (13).

Initial dressing of the extensive pelvis fractures

Damage control is a counteraction for unstable (sometimes stable) effects of pelvic bone fractures. They are responsible for a number of complications and higher mortality, particularly among patients with multiple body injuries. The aim of this treatment is, in the earliest stage of resuscitation, the acquisition
Damage control

of attitudes and stabilization of the outer ring of the pelvis, thereby reducing the loss of blood to the retroperitoneal space (14). It is certainly a safer treatment than, usually doomed to failure, attempts to review the operational retroperitoneal space. Sometimes, in return, retroperitoneal space packing is suggested.

The alternative in those and other cases, are modern possibilities of radiology intervention. Now, from a technical point of view, virtually every artery has become more available, and thanks to aggressive angiography and embolisation each heavy haemorrhage can be stopped. This technique also allows for the introduction of bypasses damaged in the vascular space. Probably in the future it will be possible to perform a routine treatment of current lethal damage of not only large arteries but also large veins (15-18).

Emergency stabilization of long bone fractures

In a deep shock injury, treatment of long bone fractures is also a problem. This is a very wide separate issue which does not fall within the framework of this article.

Abbreviated laparotomy

Abbreviated laparotomy, among other abbreviated surgical procedures, has gained an increasing recognition and become more widely used (fig. 1).

The idea of a surgery reduced to a strictly necessary minimum is not entirely new (19). Pringle can be considered as a precursor of such an idea. He used the surgery in practice as early as the year 1908. His follower Whipple also used it in 1940s. Later, however, the surgery was stopped for a long time, and in 1970s came back in a completely revised form.

In patients with abdominal injuries, in uncontrolled concussions, a diagnostic proceeding is based on a physical and, usually, ultrasound examination. Spiral computed tomography – "whole body scan" i.e. tomography from the tip of the head to pubic symphysis is increasingly used in the leading western clinics. Despite all this, even if it is available immediately, i.e. on the way from the emergency room to the operating room, it takes at least 15 minutes and can not be used with patients who suffer from a heavy loss of blood. In contrast, ultrasound in the methodology of FAST (Focused Assess-
ment with Sonography for Trauma) allows us to recognize not only the abdominal haemorrhage, but also pneumothorax, fluid in the pleural cavity and pericardial sac within 2–3 minutes. Diagnosis ends with taking blood samples from a patient to check blood type, and for blood match and laboratory tests, of which, at this stage of treatment, only a balance acid-base and lactate levels are important as therapeutic and up-and-coming factors. The patient is transported to an operating room in a few minutes. Specific damage is identified during the surgery.

Abbreviated laparotomy is a chirurgical strategy, which puts aside immediate and overall repair of all damaged organs so as to keep a proper balance in the conduct of the pathophysiological body response to trauma. This procedure is already divided into, not three, but even five stages, hence the name equivalent – staged laparatomy:

- Stage one: a decision on treatment is taken after confirming abdominal injuries which are accompanied with hypothermia, acidosis and coagulation disorders after a serious trauma which a patient after concussion suffers from.

- Stage two: a quick initial surgery is performed to stop haemorrhage and prevent abdominal cavity. The following can be used: hand compression, removal of a bleeding spleen, liver and/or retroperitoneal space packing, temporary closure of torn large vessels, temporary closure of an open intestine using a purse string suture, staple or intestine ligation (in the case of many injuries multi-staple resection without anastomosis) and precise closure of layers (without drainage!). Usually it is necessary to use decompression sutures, and the closure of the wound with a film is the most recommended, what can avoid frequent complications such as hypertension in the abdominal cavity (abdominal compartment syndrome), and what facilitates the re-opening of the abdomen.

- Stage three: in intensive care, it is a struggle to restore normal clinical and laboratory parameters of blood flow in a circuit.

- Stage four: it is a re-surgery which is done rather within 6–24 than 72 hours, depending on the type of damage. Its purpose is packing removal, the final assessment of liver damage, the definitive restoration of blood flow to organs, the restoration of the continuity of the gastrointestinal tract, the identification and repair of previously undiagnosed lesions.

- Stage five: It is the closure of the abdominal cavity which depends highly on size and location of damage and possible risks of infectious complications or signs of abdominal compartment syndrome. Often, instead of definitive closure of the abdominal cavity, it is advisable to apply so called open abdomen because of the possible swelling of the bowel.

Abbreviated laparotomy is better located in the broad scheme of resuscitation process than in a surgical treatment as such, and the final outcome of treatment depends more on adaptability and body defence system (both in the acute and later) than even the most skilled hands of a surgeon (20). The issue whether to choose an abbreviated laparotomy or a normal surgery can be seen differently: the choice of the traditional methods may mean a „well-treated patient, but a dead patient.” As far as I know, Otmar Gedliczka was the first person to discuss this concept in his speech at the congress of Polish surgeons in Katowice. Together we discussed the matter extensively in the literature of multiple surgical injury for the same year, and again I came back to the subject in 2000 at Eurosurgery in Cracow (21). At the same session, Broos from the Netherlands focused on the matter, for whom this procedure is the basis for any resuscitation action in the most severe cases of injury with heavy haemorrhage into the abdomen (22). Also Lipiński and Lasek (23) from Gdańsk placed abbreviated laparotomy in the algorithm of procedures in multiple surgical injury. Moreover, Bielecki from Warsaw promotes the idea where possible (most recently he has done that at the Surgeons’ Forum in Warsaw (24) and a conference in Cracow.

Indications for the selection of such tactics should occur after opening the abdomen, above all, after confirming multi-organ injuries, when, according to the surgeon, classical restorative operation is beyond the patient’s physiological possibilities, or is technically very difficult and time-consuming. These relate to situations when:

1) haemostasis can not be obtained due to the coagulopathy,
2) there is a damage to the large vein which can not be reached,
3) time consuming procedures are necessary when the body system response to resuscitation is poor,
4) there is a need for another, immediate, beyond-abdominal treatment that saves the patient’s life,
5) there may be a necessity for another laparotomy,
6) it is impossible to close the abdominal cavity because of oedema of organs.

The critical concern also indicates the ability of the surgeon to control bleeding, severity of injury (ISS greater than 50 points) and the presence of other damage. Packing should always be done when it is supposed to protect the patient against further loss of blood. To perform abbreviated laparotomy the following indicators should be taken into consideration: a fall in pressure lasting more than an hour, a drop in temperature below 34°C, time of prothrombinogen over 19 seconds and of thromboplastin more than 60 seconds, acidosis (pH below 7.2) and lactate levels above 4 mmol/L. In spite of so many parameters taken into account, there is the impression that this procedure can be overused, therefore sometimes published results, reaching a few dozen per cent of efficiency are so excellent. It is estimated that 10 to 40% (!) of patients survive abbreviated laparotomy. It is a huge progress compared to the classical surgical methods used previously (25), especially taking into account the patient’s almost zero chance to survive. It must be stressed here that such treatments are, and can only be performed, when the patient is in a critical state, in uncontrolled trauma.

One of the most important situations in which abbreviated laparotomy may be performed are open abdominal injuries, especially gunshot wounds (26).

According to Jacome and Hunt, however, it is vital to deal with bleeding immediately, shorten the time spent in the operating room to a minimum and intensify treatment in terms of the OIT before the second phase of the operation (27).

RESULTS

In our center, 1,747 patients underwent the diagnosis because of the suspected abdominal organ injuries. 208 patients were operated for this reason (11.9%). Mostly laparotomy was used (173, 83.2%), more seldom laparoscopy (15), and in 4 cases thoracotomy which was used to suture abdominal injuries. 16 (7.7%) patients were eligible for emergency laparotomy. In all cases it included the implementation of packing to stop bleeding (for 13 patients with damaged liver and for other 3 retroperitoneal space due to pelvic fracture).

All patients were admitted in haemorrhagic trauma. Most (11) experienced multiple injuries with a significant gravity (average of 51 points. ISS and 4.5 points. AIS to abdominal cavities, respectively 15 and 5.2 points. LSO). The remaining 5 experienced isolated abdominal injuries with an average severity of 4.8 points both in the AIS as LSO. Only in 4 patients an isolated liver damage was found, and in 3 large retroperitoneal haematoma. In other cases, the injuries were multi-organ. In addition to liver damage, spleen – 7, intestine – 4, kidney – 3, pancreatic – 1 and gall-bladder – 1 damages were found. In 4 patients with the MOC, it was necessary to perform other further emergency procedures; pleural drain in all patients, external pelvic stabilization – 2, or long bone fracture – 1. Three patients were given recombinant factor VIIa. All patients were operated shortly after the admission (on average after a period of just over 1 hour). Relaparotomy was performed after 48-72 hours. During the first relaparotomy 3 patients were failed to have the coating in the abdominal cavity closed. 11 patients (69%) died as a result of injuries (28).

Abbreviated laparotomy may also have a different risk: „previously hemostasis, then SIRS (systemic inflammatory response syndrome) (29). The increased content of exotoxin and the level of mediators were found, even with negative bacterial culture. In consequence there was an increase in the activity of neutrophils and, therefore, the occurrence or severity of the inflammatory response.

CONCLUSION

There are different views on the subject which patients are eligible to so unusual, extraordinary and often debatable procedures. On the one hand, it seems that they should be limited to critical cases, where you can no longer harm a patient by the oversight or omis-
sion, but on the other hand, perhaps it will, especially after further improvement of the surgical diagnosis, turn out that these procedures can be used much more frequently, increase the safety of the patient and protect him from too extensive initial surgery.

There is a common concept for all these treatments that the final disposition of the patient, under the worst condition, often referred to as a critical („dying patient”) is not only the immediate removal of the direct causes of life-threatening conditions (haemorrhage, respiratory insufficiency, intracranial hypertension syndrome), but also a decrease in operational trauma during the acute period. This is due to the adoption of the theory of „second blow” describing the development of traumatic disease. The transition from a, typical for all injuries (varying in intensity of course), generalized inflammatory response to the trauma system (systemic inflammatory response syndrome – SIRS) to organ failure (organ dysfunction syndrome) and multiorgan dysfunction (multiorgan dysfunction syndrome – MODS) is a corollary of the persistent shock and severe hypoxia, leading to the development of the triad (or spiral) of death. A prolonging surgery should therefore be treated as „second blow” because it requires anaesthesia, usually a general one, and it does not foster volume of whole blood in a circulatory system and acidosis, but increases hypothermia almost regardless of medical actions taken, deepens the coagulation disorders and above all, increases the need for blood transfusion what is extremely harmful in severe trauma in terms of future lung and kidney complications.

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