PEDIATRIC SURGERY *Update**
Vol. 57 No. 06 DECEMBER 2021

Acute Traumatic Coagulopathy

Trauma causes over 4 million deaths per year in the USA. Most potentially preventable deaths are due to bleeding. Disruption of the hemostatic equilibrium occurs at the moment of traumatic impact in children and adults. Tissue injury and blood loss during trauma causes an endogenous acute coagulopathy referred to as acute traumatic coagulopathy (ATC). Traumatic injury generates dysfunction of the coagulation, anticoagulation, and fibrinolysis system, featuring a hypocoagulant state with prolongation of the prothrombin time (PT) and/or activated partial thromboplastin time (aPTT). The PT and INR have been suggested as the more sensitive test to the multiple coagulation factor deficiencies associated to ATC. ATC develops rapidly and has been identified within minutes of injury. Severe tissue trauma and systemic hypoperfusion are prerequisites for development of ATC. The worst coagulopathy is seen in patients with injury severity scores above 35 and base deficits less than 12 mEq/L. Other's mediators such as hypothermia, acidosis, and hemodilution develop later after injury due to hemorrhage, hypoperfusion and exposure and resuscitation with hypocoagulable products. Presence of ATC during hospital admission is independently associated with fourfold higher mortality and significantly greater transfusion requirements. The overall length of mechanical ventilation, ICU and hospital stay is longer in injured patients with acute traumatic coagulopathy versus those with normal hemostasis on admission. Patients presenting with ATC have a mortality approaching 50%. An INR greater than 1.3 on admission is the most predictive of risk of death over other characteristics labs. The higher the INR the higher the risk of mortality. Endogenous systemic anticoagulation and fibrinolysis have emerged as probable mediator of ATC. Coagulation is acutely impaired after injury, starting with fibrinogen concentration declining rapidly. Systemic anticoagulation via activation of protein C is the most important functional mediator of ATC. Fibrinolysis is also a functional component of ATC. Injury and hemorrhagic shock cause primary platelet impairment. The vascular endothelium is an active participant in the pathophysiology of ATC as it captures thrombin and accelerates protein C activation 1000-fold. ATC is not a consumptive coagulopathy, since it's characterized by dysfibrinogenemia, systemic anticoagulation, impaired platelets function and hyperfibrinolysis. The most consumed coagulation factors following injury are fibrinogen and factor V. Reproducing whole blood by transfusing injured patients with a balanced ratio of packed blood red cells, fresh frozen plasma and platelets while minimizing crystalloid resuscitation is associated with a reduced mortality. High doses of fresh frozen plasma (10-20 ml/kg) are recommended to control the severe traumatic bleeding as soon as possible. FFP and PRBC at a predetermined ratio of 1:2 is recommended. Platelet transfusions are recommended to maintain a goal above 50K/L in polytrauma, and >

100K/L in central nervous system injury. Correction of hyperfibrinolysis using tranexamic acid is the final component to effective damage control resuscitation.

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PICC Lines

Vascular access is a very important aspect of care for children and adults. Peripheral inserted central venous catheters (PICC) lines are required by almost one-third of neonates and children admitted to intensive care units. Indications for PICC lines include intravenous access, long-term antibiotics therapy, infusion of blood products and total parenteral nutrition. Using ultrasound guidance, PICC lines are easy and safe to insert due to placement in a peripheral vein in the upper limb (cephalic or basilic vein) with the tip at a central location in the superior or inferior vena cava allowing high osmolality solutions to be delivered. Risk of hemothorax and pneumothorax associated to central line placement is also avoided. The use of the axillary vein for PICC line insertion in premature neonates can significantly reduce the frequency of complications. Infants with abdominal surgical pathology who have PICC lines placed in the lower limb are at greater risk for major complications related to venous thromboembolism. PICC lines are inserted ultrasound-guided either using the modified Seldinger technique or the direct sheathed-needle puncture technique. Both have similar complication rates. The tip of the PICC lines is confirmed with a standard chest film. The most common complications of PICC lines include in order of frequency local inflammation at the site of insertion (redness and swelling), infection with sepsis, thromboembolism and mechanical. An infection occurs when there is a positive peripheral or central blood culture or a positive catheter tip culture after removal in the presence of clinical signs of catheter-related sepsis. The surgical neonate has a PICC infection rate of 10-25% comparable to the infection rate of Broviac catheters. Coagulase-negative staphylococcus is the most common organism isolated from positive cultures in PICC lines. Attempted catheter sterilization with antibiotics can lead to complicated bacteremia. Complicated bacteremia is defined as the presence of end-organ damage, multiple positive blood cultures or death. End-organ damage is defined as presence of osteomyelitis, vital organ abscess, positive echocardiogram with vegetation, or a positive lumbar puncture. Lack of improvement of inflammatory markers or two positive blood cultures in spite antibiotics therapy for sepsis needs line removal. Recommendations to reduce the incidence of catheter associated bloodstream infection (CABSI) include cleaning hands before placement, wearing full barrier precautions during insertion, using

chlorhexidine to clean the skin, using prepackaged insertion bundles, and assessing the daily need for the line. There is also a decrease in CABSI when lines are placed in the operating room. Withdrawing blood from catheters less than 3 Fr increase the occlusion rate of PICC lines. The use of central lines is the most common cause for thrombosis in neonates and infants preterm babies. Catheter-related venous thromboembolism can be asymptomatic or can result in complications such as deep vein thrombosis, portal vein thrombosis, Budd-Chiari, superior vena cava syndrome, intracardiac thrombosis or pulmonary embolism.

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Congenital Thrombophilia

Thrombophilia is defined as an increased risk of developing hypercoagulability and venous thrombosis. Thrombophilia may be congenital or acquired. Although thrombosis may occur in either or both venous and arterial vessels, the term thrombophilia is usually utilized for venous thromboembolism (VTE). Main causes of congenital thrombophilia are classified as loss of function such as deficiency of antithrombin, protein C and protein S, or a gain of function such as activated protein C resistance due to factor V Leiden mutation, hyperprothrombinemia due to presence of the prothrombin mutation, or dysfibrinogenemia due to impairment of the relevant metabolic pathway. Acquired risk factors for developing thrombophilia include antiphospholipid antibodies, detected as lupus anticoagulants and/or anticardiolipin antibodies and/or anti-B-2-glycoprotein-I antibodies. Laboratory testing for thrombophilia should be undertaken in any young patients who experience an unprovoked thrombotic event and those with recurrences. The identification of risk factors may permit genetic counseling, modification of the patient lifestyle to avoid future risk and the ability to identify relatives at risk. Thrombophilia testing does not substantially help to predict or reduce the incidence of thrombosis recurrence. The intensity and duration of anticoagulation treatment for thrombophilia after a thrombotic event should not be altered irrespective of the presence or absence of most thrombophilia risk factors. It is

recommended that thrombophilia testing be offered to patients with a first VTE < than 50 years of age, recurrent VTE, VTE at any age with a strong family history of thrombotic disease and VTE occurring in unusual sites such as hepatic, mesenteric, portal, and cerebral veins. It is also recommended testing be offered to women suffering VTE in association with pregnancy, the immediate postpartum period, or oral contraceptive use. Most pediatric VTE are associated with indwelling catheters and/or underlying medical conditions, including congenital heart disease, inflammation, immobilization, thrombophilia, or malignancy. Portal vein thrombosis is associated with umbilical venous catheter placement in neonates and is likely very common. Other thrombotic conditions in neonates include purpura fulminans, renal vein thrombosis and cerebral sinovenous thrombosis. Deep vein thrombosis is the most common presentation of VTE in children and indwelling catheterization is the most common trigger factor. Congenital heart disease predisposes to both venous and arterial thrombosis, especially in shunting lesions and those requiring catheterization, surgery and/or ECMO. Arterial thrombosis is uncommon in pediatrics and is nearly always associated with arterial trauma or catheterization. In cases of thrombophilia the goal of therapy should be rapid restoration of blood flow to reduce late effects. For treatment of VTE most children receive six weeks to six months of therapeutic anticoagulation. Tissue plasminogen activator (tPA) is utilized for thrombolysis of venous or arterial thrombi that are life, limb or organs threatening. Antiplatelet agents are used in pediatrics to prevent arterial thrombosis or thrombosis associated with congenital heart disease. Patients with cancer with a central venous catheter and factor V Leiden mutation have a higher risk of developing catheter-related thrombosis. Severe thrombophilia might increase the risk of thrombosis in Covid-19 patients.

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**** PSU 1993-2021***

ISSN 1089-7739