**Point-of-care coagulation monitoring in the OR: Reduced bleeding and less transfusion?**

**Definitions**
Bleeding in the OR may be minimal, severe, organ- or life-threatening depending on the amount and location of the bleeding site. Reductions in minimal blood loss may contribute to an increase in overall patient safety e.g. by reducing complications secondary to hematoma formation. However, reductions in the incidence and magnitude of severe to massive blood loss in elective and emergency surgery are of higher clinical relevance. Accordingly, this lecture will focus on severe to massive bleeding events which usually increase the risks of coagulopathy, tissue hypoperfusion, anemia, and allogeneic blood product transfusions. Severe bleeding is defined as a blood loss > 20% of the patients blood volume. Massive transfusion is commonly defined as a replacement of 100% blood volume over a period of 24 h or the transfusion of 4 red blood cell concentrates (RBC) within 1 h when ongoing need is foreseeable. Organ damage can results e.g. from bleeding intracranial or intraocular.

**Risks of bleeding and transfusion**
Coagulopathy is a well accepted risk for further perioperative bleeding in a bloody vitious circle; hypoperfusion in the macro- and microcirculation and anemia are well accepted risk factors for vital organ dysfunctions and predictors of survival. Interestingly, the risks and limitations of allogeneic blood product transfusion are often ignored. Although red blood cell (RBC) transfusion is required to maintain oxygen delivery and hemoglobin levels of about 7-9 g dl\(^{-1}\) in severe bleeding (1), morbidity and mortality are increased in transfused patients (2). Platelet concentrates may increase platelet counts and reverse (pharmacological) platelet dysfunction but also morbidity and mortality (3). Fresh frozen plasma (FFP) was efficacious in only 1/3 of perioperative studies (4) but carries relevant risks of transfusion-associated immunomodulation, acute lung injury, infection, mortality (1). Together, unjustified transfusion of all labile allogeneic blood products must be avoided in order to improve short- and long-term patient outcome, to increase availability of these scarce resources for patients in need, and to reduce health care costs.

**Benefit from laboratory tests**
It is not a test itself but rather the therapeutic and/or logistic consequence in patient management following indicative tests results what improves quality of care. It is not the performance of a point-of-care coagulation tests (POCT) in the OR what reduces bleeding and transfusion needs but rather the implementation of POCT into medical decision making and – ideally - into a treatment algorithm with predefined, individualized cut-off values for therapeutic interventions. The strength of POCT in bleeding management is the prompt detection of the leading pathomechanism(s) of bleeding which permits fast and targeted correction. Thereby, an early goal-directed bleeding management may prevent further blood loss and transfusion requirements and secondary - by avoiding their respective risks - improve outcome, survival, and cost-effectiveness. The primary outcome benefit of reduced bleeding has been confirmed by a Cochrane review for
viscoelastic POCT including rotational thromboelastometry (ROTEM) and thrombelastography (TEG).(5) More recent randomized clinical trials extended this observation for secondary outcome benefits.(6,7) According to the growing body of evidence the upcoming guideline of severe perioperative bleeding management of the European Society of Anesthesiology (ESA) recommends “the application of transfusion algorithms incorporating predefined intervention triggers based on POC coagulation monitoring assays to guide haemostatic interventions … (1C)”.(1)

Viscoelastic POCT

Point-of-care tests should have only one pipetting step per methodological definition; viscoelastic tests ROTEM and TEG traditionally require more steps (except for the novel single-reagent ROTEM test kits). Most important, point-of-care tests should deliver test results in a timely manner per clinical definition; indicative results of clotting time (CT), clot formation time (CFT), amplitude 10 (A10), comparison of these values in corresponding assays (EXTEM – APTEM, EXTEM – FIBTEM, INTEM – HEPTEM) permit differential diagnosis of coagulopathy within 10-15 mins. Tests methodology is presented elsewhere.(8) In brief, not only the time until initial fibrin strand formation are recorded (similar to the routine plasma-based tests aPTT, PT, TT) but also the dynamics of clot formation and the quality of the clot are analyzed in whole blood. These functional parameters correlate with the risk of bleeding.

Routine coagulation tests and platelet function tests

Routine coagulation test panel reports (aPTT, PT, INR, TT, fibrinogen levels) require 30-45 mins depending on the logistics of a hospital. Even if performed faster in hand-held devices in the OR, routine lab results are not sensitive for critical pathomechanisms of bleeding including hyperfibrinolysis and fibrinogen polymerization. Accordingly, therapeutic misadventures may occur.
Platelet function tests may be suggested pre-operatively to identify decreased platelet function caused by medical conditions and antiplatelet medication (2C).(1) Platelet function tests performed at the point-of-care in the OR may facilitate differential indication for desmopressin, platelet transfusion, recombinant factor VIIa versus other procoagulant strategies.(6,7)

Strategies to reduce bleeding

Massive blood loss in the operating theatre should be stopped promptly by surgical and/or goal-directed procoagulant interventions in order to avoid risks of bleeding and transfusion. As for procoagulant therapy, also volume therapy should be individualized and targeted to the actual needs. Hypovolemia is a well accepted risk factor but also hypervolemia has negative effects e.g. on the endothelial glycocalyx with its unwanted consequences of interstitial edema. Colloid-induced coagulopathy is dose- and macromolecule-dependent.
Before massive blood loss occurs, it should be avoided by pre-operative means of risk assessment and patient optimization including pre-operative correction of coagulopathy and anaemia. Thereby, the patient’s tolerance to blood loss is increased. The upcoming ESA guidelines on the management of severe perioperative bleeding will give evidence-based guidance in this complex medicinal field from
pre-operative patient optimization to an intraoperative rational, goal-directed bleeding management to an individualized perioperative fluid therapy. (1)

At the conclusion of this lecture, the participant will be able to:
- Discuss short- and long-term adverse effects of allogeneic blood product transfusions including acute lung injury, immunomodulation, infections and mortality
- Understand the clinical relevance and value of strategies intended to reduce transfusion requirements including goal-directed (point-of-care test-based) coagulation management
- Discuss the definition of point-of-care coagulation tests and understand their methodology including routine, viscoelastic, and platelet function tests
- Appraisal of the evidence in this field including signals in low-quality studies as well as RCTs in the respective Cochrane analysis and in the systematic review in the ESA guideline on severe perioperative bleeding management

References
8) www.perioperativebleeding.org, last access December 2012

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