Hemostasis in neurosurgery

- One of the most important aspects of surgery.
- Control of bleeding without ligature unlike in abdominal and other surgeries ligatures and packs rarely useful.
- Many hours lost in bleeding control
Topical hemostats

- Agents that help in controlling bleeding.
- Ideal topical hemostat:
  - safety,
  - efficacy,
  - usability,
  - cost, and
  - Approvability
Sources of bleeding

- Scalp/muscles
- Bone
- Dura and sinuses
- Brain: capillary/venous/arterial
Muscle
- 1st used by Sir Harvey Cushing
- Mechanism: mechanical plus as a source of tissue thromboplastin.

Cotton Balls and Cotton Patties
- Mainly mechanical by applying gentle pressure.
Gelatin sponge (Gelfoam)

- Introduced in the 1940s for neurosurgical procedures.
- Derived from purified pork skin gelatin.
- Mechanical barriers to bleeding by forming a matrix.
- Absorbs approximately 45 times its weight in blood and can expand to approximately 200% of its initial volume.
- Not to be used in combination with blood salvage equipments as their fibres can pass through the 40 mm filters of salvage systems.
- Can be used dry or saline soaked, better when excess saline is removed as compare to supersaturated.
Microfibrillar collagen (Avitene)

- Collagen which is derived from bovine skin binds tightly to blood surfaces.
- Causes minimal swelling especially when compared to Gelfoam.
- serving as a matrix for clot formation and enhancing platelet aggregation, degranulation, and release of clotting factors which then combine with plasma factors to produce fibrin clot
- May reduce the number of free platelets in normal individuals.
- Loses effectiveness in thrombocytopenia (<10,000).
- It is absorbed in 3 months and needs to be applied dry.
Oxidised regenerated cellulose (Surgicel)

- Introduced in 1940s.
- Surgicel (Ethicon) is an oxidized cellulose polymer (the functional unit is poly anhydroglucuronic acid) formed by dissolving pure $\alpha$-cellulose (plant derived) in an alkaline solution.
- It is then regenerated into continuous fiber, knitted into gauze, and oxidized.
- Applied dry, absorbs within 4 to 8 weeks.
- Forms a brownish or black gelatinous mass in contact with blood.
- Acts as a physical matrix to which platelets can adhere which, in turn, aids in clot formation.
- Additional pressure of the mass also contributes to the haemostatic process.
- They create an acidic environment and are bactericidal.
- Cellulosic acid facilitates hemostasis by denaturing blood proteins.
- Needs to be applied dry.
- They can be best removed by gentle irrigation with saline.
• Oxycel (Becton Dickinson) is another oxidized cellulose polymer product that is similar.
• Surgicel is composed of solid fibers with irregular contours on cross-section, whereas Oxycel is composed of hollow “twisted tubule” fibers.
SURGICEL Fibrillar

- Oxidized regenerated cellulose (1969)
- Layers can be peeled off in desired amounts.
- Conforms to irregular surfaces, even hard-to-reach areas
- Surgical visualisation is improved by ability to cauterise directly through it
- Fully absorbed within 14 days
Rapid closure technique in decompressive craniectomy. Güresir E, Vatter H, Schuss P, Oszvald A, Raabe A, Seifert V, Beck J. J Neurosurg. 2011 Apr;114(4):954-60. Epub 2010 Jan 29. Total of 314 patients. The surgical time is significantly shorter without increased complication rates or additional complications. Cranioplasty after a RCDC procedure was also feasible, fast, safe and not impaired by the RCDC technique.
Active

Thrombin

- Thrombin is marketed as bovine (Thrombin-JMI, King Pharmaceuticals, Bristol, TN), human pooled plasma (Evithrom, J&J), and recombinant (Recothrom, Zymogenetics, Seattle, WA).
- Thrombin directly activates fibrinogen and converts it into fibrin monomers.
- Can be used directly or combined with gelatin sponge
- Bovine thrombin is antigenic.
- If injected into large vessels can lead to thrombosis and complications.
The three commercially available thrombins are functionally equivalent in terms of efficacy with 95 percent or greater of patients achieving hemostasis within 10 minutes of application and approximately two-thirds of patients achieving hemostasis within 3 minutes. Chapman WC, Singla N, Genyk Y, McNeil JW, Renkens KL Jr, Reynolds TC, Murphy A, Weaver FA. A phase 3, randomized, double-blind comparative study of the efficacy and safety of topical recombinant human thrombin and bovine thrombin in surgical hemostasis. J Am Coll Surg 2007;205: 256-65
The human antibodies to bovine FII and FV have been linked to coagulopathy and potentially fatal complications.

Complications

- Nidus of infection
- Inflammatory reaction (esp. avitene)
- Antigenicity (animal products)
- Mass effect (esp. gelatin)
- Gossipiboma
Bone wax

- Pioneered by Sir Victor Horsley (1892). Horsley’s wax: bees wax, 7 parts; almond oil, 1 part; salicylic acid, 1 part.
- Modern wax: 88% refined beeswax and 12% isopropyl palmitate (softening agent).
- Effective in controlling bleeding from bone
- Once smeared across the bleeding edge, immediate hemostasis occurs.
Complications

- Bone wax inhibits osteogenesis.
- Increases infection rates (the number of bacteria needed to produce osteomyelitis is reduced by a factor of 10,000).
- Remains as a foreign body for many years.
Ostene

- Sterile mixture of water-soluble alkylene oxide copolymers.
- Inert artificial material feels and works like wax.
- Does not increase infection rates, does not interfere with bone healing, and is non-inflammatory.
Flowables

- Human plasma thrombin with bovine gelatin matrix. (*Floseal*, Baxter, Fremont, CA)
- Create a granular hemostat that employs both active and mechanical components to achieve hemostasis.
- It is applied as a paste to which it is recommended that gentle pressure be applied with a moist saline sponge for 2 minutes to achieve hemostasis.
Hemostatic matrix sealant in neurosurgery: a clinical and imaging study. Roberto Gazzeri & Marcelo Galarza & Massimiliano Neroni & Alex Alfieri & Marco Giordano. Acta Neurochir (2011) 153:148–155. Effective hemostasis, defined as cessation of bleeding, was achieved no later than 3 min after topical agent application in all patients except in 11 cases out of 214 cases it was used.
<table>
<thead>
<tr>
<th>Complication</th>
<th>Number of patients (%)</th>
<th>Pathology</th>
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<tbody>
<tr>
<td>Rebleeding</td>
<td>4 (1.8)</td>
<td>2 malignant gliomas, 1 spontaneous ICH, 1 traumatic ICH</td>
</tr>
<tr>
<td>Abscess</td>
<td>1 (0.4)</td>
<td>1 malignant glioma</td>
</tr>
<tr>
<td>Status epilepticus</td>
<td>1 (0.4)</td>
<td>1 extra-axial hematoma</td>
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A study in cardiac, vascular, and spinal or orthopedic patients designed to show equivalence between bovine thrombin gelatin matrix and bovine thrombin with porcine gelatin sponge demonstrated statistically significant (p < 0.001) superiority of the flowable matrix product for percent of patients with hemostasis at 10 minutes, 96 percent (149/156) versus 77 percent (118/153). Package Insert. Floseal, Baxter. 2005.
Fibrin sealent

- Human plasma derived fibrin sealent
- **Fibrin glue** (Tisseel/evicel)
- Commercially available/autologous.
- 2 components:
  - a) fibrinogen, factor 13, fibronectin, aprotinin, plasminogen, cryoprecipitate
  - b) thrombin and calcium
- After mixing, fibrinogen is converted to fibrin
- Aprotinin inhibits premature fibrin degradation
Supply a source of fibrinogen to the site of injury and do not need active bleeding or blood-derived fibrinogen to polymerize.
Use

- For hemostasis and tissue sealing
- To reinforce dural closure and prevent CSF leak.
- In anastomosis of nerves and nerve grafts
- Fixation of bone fragments to repair skull defects.
Hydrogen peroxide

- 3% solution is used in neurosurgery
- Use is very controversial
- Mechanism: mechanical obstruction of the microvasculature, mechanical removal of tissue debris, and vasoconstriction. Exact mechanism is not known.
- Primarily used to achieve hemostasis after complete tumor removal of the surrounding arachnoidal surface of the brain.
Recent evidence suggest significant tissue damage in surrounding functional brain.


Avitene, FloSeal, and Surgicel performed better (defined as complete hemostasis within 1 minute) than control (no treatment). Residual material was not present at any time with Arista, markedly contrasting with the presence of residual material in 100% of lesions in the Avitene, FloSeal, and Surgicel groups on Day 14. Avitene and FloSeal also demonstrated a propensity for causing granuloma formation, whereas Arista and Surgicel showed no such evidence.

• The use of absorbable porcine gelatine and regenerated, oxidised cellulose as haemostats in intraspinal surgery must be considered safe and beneficial. However, the appropriate use of haemostats requires a certain understanding of their advantages, limitations and the nature of complications associated with their application
Conclusion

- Proper surgical principle remains the key.
- Judicious use of hemosatic agents is advised.