Innovative Therapy in Traumatic Brain Injury (TBI)

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Body as series of compartments: compartment syndrome — elevated compartmental pressure limits venous return, which leads to increased pressure and, ultimately, arterial insufficiency; seen most often in lower extremities; pressure transmitted among various compartments of body; abdominal compartment syndrome — may develop secondary to elevated pressure in other compartments; patients undergoing massive resuscitation may develop visceral abdominal edema even in absence of abdominal injuries

Tension pneumothorax: can be thought of as thoracic compartment syndrome; decompression with chest tube equivalent of “chest fasciotomy”

Cardiac tamponade: mediastinal compartment syndrome; “fasciotomy” is pericardiotomy and evacuation of blood

Intracranial pressure (ICP): related to cerebral perfusion pressure (CPP) and intra-abdominal pressure independently of cardiovascular or pulmonary function; elevated intra-abdominal pressure leads to increases in intrathoracic and central venous pressure, with decreases in cerebral venous outflow and increased ICP; in animal models of intracranial hypertension, opening sternum associated with decrease in ICP; in subsequent studies of humans with intractable intracranial hypertension, opening abdomen associated with fall in ICP; theory — ICP rises, CPP falls; blood pressure falls when patient sedated according to algorithm; patient develops interstitial edema when fluid administered and mechanical ventilation started; subsequent elevations in intrathoracic and intra-abdominal pressures lead to rise in ICP

Dual decompressive therapy: decompressive craniectomy and decompressive laparotomy always associated with decrease in ICP (and in peak airway pressures) in patients with intracranial hypertension, regardless of whether craniectomy or laparotomy performed first; peak airway pressure did not change if decompressive craniectomy performed alone; can also lower ICP by raising patient to standing position on tilt table

Monitoring ICP and CPP: to determine changes in patients with TBI, data filtered every 6 sec; means determined every 5 min; degree and duration of ICP and CPP above and below treatment thresholds calculated as pressure times time dose (PTD); in comparison of automated vs manual data gathering, automated data collection significantly more accurate at detecting PTDs associated with poor outcomes; total PTD correlated with length of intensive care unit and hospital stay and Glasgow Coma Scale scores at discharge; early PTD measures for unfavorable CPP predicted need for craniectomy

Brain trauma index (BTI): CPP divided by ICP; quartile 1 (normal) — CPP <60 mm Hg; ICP <20 mm Hg; BTI good predictor of mortality and score on Extended Glasgow Outcome Scale (measure of long-term functional outcomes)

Brief episodes of intracranial hypertension: ie, those lasting <5 min; correlate strongly with functional outcomes and mortality

Enhancing outcomes associated with TBI: important to create safe “cocoon” within which brain can recover; percentage of time with systolic blood pressure <100 mm Hg predicts outcome at 1 yr; time at <120 mm Hg predicts mortality; this calls into question acceptability of maintaining systolic blood pressure at ≥110 mm Hg, as long as cerebral perfusion maintained; outcomes associated with hyperoxia (PaO2 >200 mm Hg) as detrimental as those with hypoxia (extra oxygen may create reperfusion injury in brain); reliance on CPP, central venous pressure, and wedge pressure ignores issues of cardiac compliance; speaker and colleagues have developed focused rapid echocardiographic evaluation (echocardiography program performed by intensivist that permits echocardiography every 5 min, if necessary); switched

Educational Objectives

The goal of this program is to improve outcomes of trauma and critical care patients. After hearing and assimilating this program, the clinician will be better able to:

1. Manage intracranial hypertension by manipulating intrathoracic and intra-abdominal pressure.
2. Calculate a patient’s brain trauma index and use it to guide management of traumatic brain injury (TBI).
3. Recognize which TBI patients are at highest risk of developing deep venous thrombosis (DVT).
4. Assess the benefits and risks associated with pharmacologic and nonpharmacologic methods of preventing DVT in patients with TBI.
5. Choose the most appropriate antibiotics for empiric coverage in the intensive care unit.

Faculty Disclosure

In adherence to ACCME Standards for Commercial Support, Audio-Digest requires all faculty and members of the planning committee to disclose relevant financial relationships within the past 12 months that might create any personal conflicts of interest. Any identified conflicts were resolved to ensure that this educational activity promotes quality in health care and not a proprietary business or commercial interest. For this program, the faculty and planning committee reported nothing to disclose.
emphasizing from pressure to dynamic cardiac function; readings changed care in >50% of cases

**Conclusions:** brain injury is whole-body disease (body compartments connect); vital signs underestimate pathol-

ogy; standard intensive care misses much; new therapeu-
tic tools focus on nonbrain therapies and use better informa-
tion; in future, computerized decision trees will drive care and warn clinicians of impending devastating events

**A Practical Approach to Deep Venous Thrombosis**

**Prophylaxis in TBI**

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**Overview:** in study lasting 6.5 yr at level 1 trauma center, authors used sequential compression devices (SCDs) on legs to prevent deep venous thrombosis (DVT) in patients with head trauma; no anticoagulants used; of 939 patients, 677 met criteria (moderate to severe brain injury; hospital stay >7 days); 214 patients (30%) developed DVT; on univariate analysis, risk factors included subarachnoid hemorrhage, lower extremity injury, and longer length of stay in hospital or intensive care unit (ICU); on multivariate analysis, male sex, age >55 yr, and higher injury severity score also emerged as risk factors; study shows incidence of DVT high when SCDs used as sole mode of prophylaxis

Inferior vena cava (IVC) filters: indicated in cases of prox-

imal thrombus in thigh if patient cannot undergo full anticoagulation; prophylactic use controversial; if not rapidly and adequately treated; femoral clot may pro-

duce long-term disability; IVC filter may prevent DVT, but does not prevent sequelae of clot in leg (prophylactic anticoagulation necessary even if IVC filter used)

**Pharmacologic thromboprophylaxis:** in study by Nor-

wood and colleagues, administration of enoxaparin within 48 hr of injury associated with worsening of hemorrhage (requiring change in treatment) in 1% of patients; authors concluded enoxaparin safe and effective, based on low incidence of bleeding; study unconvincing due to excessively strict exclusion criteria and frequent protocol violations; Levy and colleagues studied 221 patients with TBI given pharmacologic prophylaxis (enoxaparin and/or unfractionated hepa-

rin) median 3 days after injury; 148 patients received continuous treatment; of patients receiving prophyl-

axis, 13 developed DVT, 3 developed pulmonary emboli, and 73 developed progression of hemorrhage; of 119 patients given SCDs only, 2 developed DVTs, 1 developed pulmonary embolism, and 37 developed progression of hemorrhage; authors concluded that pharmacologic prophylaxis contributed to progression of hemorrhage (despite finding that hemorrhage pro-

gressed also in many patients not given pharmacologic prophylaxis); in meta-analysis of 30 studies, Collen and colleagues concluded that low-molecular-weight heparin “somewhat superior” to SCDs alone, but made no strong recommendations

Other considerations: SCDs often inconsistently applied, which contributes to poor outcomes when used as sole means of thromboprophylaxis; inconsistencies also seen with pharmacologic thromboprophylaxis (often held when patients undergoing procedures)

**Recommendations:** balance risk of exacerbating hemor-

rhage against risk of developing DVT; apply SCDs to all patients with TBI as soon as possible after admission; patients at highest risk for DVT should also receive some form of chemical prophylaxis (preferably enoxaparin or low-molecular-weight heparin); administer after risk for bleeding has subsided (varies among patients; appropriate time usually when bleeding from other injuries has stopped, but no earlier than 48 hr after TBI; perform computed tomography to ensure bleeding no longer pro-

gressing); if patient cannot receive chemoprophylaxis, monitor with frequent duplex surveillance

**Antibiotics in the Intensive Care Unit**

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**Antimicrobial stewardship programs:** developed to promote appropriate selection of antibiotics, and thereby achieve optimal patient outcomes; adequate initial therapy must be provided for patients with severe sepsis and septic shock

Factors to consider in choosing adequate initial therapy: patient-specific features (eg, previous use of antibiotics, previous exposure to resistant organisms, type of organism most likely causing infection); susceptibili-
ties of infecting organisms in local community; institutional epidemiology of infections

**Principles of empiric therapy:** start broad-spectrum antimicrobials, pending results from culture; choose drug that covers *Staphylococcus aureus* (assume methicillin resistance; methicillin-resistant *S aureus* [MRSA] most common type of staphylococci seen, despite recent slowing in rate of increase), streptococci, and entero-

cocci (particularly important in nosocomial infections, although incidence of infection with vancomycin-resist-
tant enterococci decreasing slightly)

Antibiotics effective against resistant gram-positive cocci: *vancomycin* — questions concern efficacy against MRSA, other infections, and toxicity (especially nephrotoxicity); recommended trough level 5 to 15 µg/mL, or higher for serious infections (however, higher doses associated with greater risk for nephrotoxicity, and evidence for better outcomes questionable); *linezolid* (Zyvox) — advantages include broad spectrum against resistant gram-positive bacteria, and evidence of efficacy against hospital-acquired or ventilator-associated pneumonia (arguably more effective than vancomycin against MRSA ventilator-associated pneumonia); *disadvantages of linezolid* — increasing resistance in vancomycin-resistant enterococci; bacterio-

static (rather than bacteriocidal) action; serious adverse effects, such as bone marrow suppression; risk for drug-drug interactions (inhibits monoamine oxidase and interacts with selective serotonin reuptake inhibitors); cost relative to other antibiotics; *daptomycin* (Cubicin) — indicated especially for drug-resistant gram-positive cocci; bacteriocidal, with demonstrated efficacy in bactere-

mia and endocarditis; disadvantages include inactivity against pneumonia (inactivated by pulmonary surfactant);

Suggested Reading

1. Patients undergoing massive resuscitation may develop visceral abdominal edema even if they have not suffered abdominal injuries.
   (A) True  (B) False

2. Identify the accurate statement about dual decompressive therapy.
   (A) Decreases intracranial pressure in 50% of cases
   (B) Craniectomy should be performed first
   (C) Laparotomy should be performed first
   (D) Craniectomy alone not associated with changes in peak airway pressure

3. Which of the following is considered a normal brain trauma index?
   (A) <60 mm Hg  (B) 60 to 75 mm Hg  (C) 75 to 100 mm Hg  (D) 100 to 120 mm Hg

4. Episodes of intracranial hypertension lasting ≤5 min do not affect outcomes.
   (A) True  (B) False

5. In a patient with a traumatic brain injury (TBI), 1-yr mortality is correlated with the percentage of time systolic blood pressure is kept below:
   (A) 140 mm Hg  (B) 130 mm Hg  (C) 120 mm Hg  (D) 110 mm Hg

6. Risk factors for deep venous thrombosis (DVT) in a patient with TBI include all the following, except:
   (A) Male sex  (B) Subarachnoid hemorrhage  (C) Upper extremity injury  (D) Age >55 yr

7. Which statement best summarizes research findings on prevention of DVT in patients with TBI?
   (A) No progression of hemorrhage seen in patients given sequential compression devices (SCDs) alone
   (B) Pharmacologic therapy more effective than SCDs at preventing DVT
   (C) No progression of hemorrhage seen with pharmacologic therapy
   (D) Progression of hemorrhage seen with both forms of therapy

8. The rate of increase in the incidence of infections with methicillin-resistant Staphylococcus aureus is ______; the incidence of infection with vancomycin-resistant enterococci has ______.
   (A) Accelerating; increased  (B) Slowing; increased  (C) Slowing; decreased  (D) Accelerating; decreased

9. Which of the following antibiotics is contraindicated for a patient taking selective serotonin reuptake inhibitors?
   (A) Vancomycin  (B) Daptomycin  (C) Linezolid  (D) Piperacillin and tazobactam

10. Choose the correct statement about tigecycline.
    (A) Ineffective against gram-negative organisms  (B) Has bacteriostatic action
     (C) Usually requires dose adjustment  (D) Effective against Pseudomonas aeruginosa

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Answers to Audio-Digest General Surgery Volume 59, Issue 20: 1-B, 2-B, 3-A, 4-A, 5-C, 6-D, 7-B, 8-A, 9-D, 10-B