A Year in Review – The 2023 Critical Care and Resuscitation Literature

Rapid Sequence Intubation

- *Prekker ME, Driver BE, Trent SA, et al. Video versus Direct Laryngoscopy for Tracheal Intubation of Critically Ill Adults. N Engl J Med. 2023. The DEVICE Trial.*
  - **Objective**
    - To compare the 1st pass success rate of direct and video laryngoscopy in critically ill adults.
  - **Methods**
    - A multicenter, unblinded, randomized, parallel- group trial conducted at 17 sites (7 ED, 10 ICUs) across 11 medical centers in the US
  - **Patients**
    - Included: critically ill adults age >18 undergoing tracheal intubation
  - **Trial Procedures**
    - Patients were randomized in a 1:1 ratio to either direct or video laryngoscopy.
    - Operator instructed to use either VL or DL on the first attempt
  - **Primary outcome**
    - First-pass success (single insertion of blade, bougie if used, and ETT)
  - **Secondary outcomes**
    - Severe complications
      - Hypoxemia (SpO2 < 80%)
      - Hypotension (SBP < 65 mm Hg)
      - New or increased vasopressor use
      - Cardiac arrest
      - Death
  - **Results**
    - The DSMB recommended stopping the trial after the first Interim analysis of 1000 patients (1st pass success higher in video laryngoscopy group (p<0.001))
    - 1417 met inclusion criteria among 1947 total assessed
      - 705 (49.8%) video laryngoscopy
      - 712 (50.2%) direct laryngoscopy
  - **Primary Outcome**
    - 1st pass success higher in video laryngoscopy group
      - Video: 600/705 (85.1%)
      - Direct: 504/712 (70.8%)
      - Absolute risk difference 14.3% (CI 9.9 to 18.7, p<0.001)
  - **Subgroup analysis**
    - What was the impact of operator experience on 1st pass success?
      - < 25 intubations much larger risk difference compared to those with > 100 prior intubations in favor of VL

# Prior intubations	Absolute Risk difference	Statistical significance?
<25	26.1%	Yes

25-100	22.2%	Yes
>100	5.9%	No

- Did location matter?
  - Still statistically significant when controlling for the location of either the ED or ICU in favor of VL

Location	Absolute Risk difference	Statistical Significance
ED	14.5%	Yes
ICU	13.9%	Yes

- Did anticipated difficulty of intubation matter?
  - Still statistically significant when controlling for anticipated difficulty in favor of VL

Anticipated Difficulty	Absolute Risk Difference	Statistical significance
Easy	11.7%	Yes
Mod	12.9%	Yes
Difficult	27.7%	Yes

- **Limitations**
  - Trial limited to ED and ICU, cannot generalize to the operating room
  - Most operators had < 250 intubations
  - Operators could select brand and shape of blade, so those factors could serve as confounder for outcome of 1st pass success
  - Excluded those who needed immediate intubation or if the operator deemed one method necessary or contraindicated. Introduces bias, perhaps more time sensitive intubations were more technically challenging or perhaps those patients were sicker.
- **Take Home Points**
  - VL was associated with a significant increase in intubation 1st pass success
  - The more junior the intubator the more helpful VL is in 1st pass success
  - The more difficult the airway is anticipated to be, the more helpful VL is in 1st pass success

Cardiac Arrest

- *Suverein MM, Delnoij TSR, Lorusso R, et al. Early extracorporeal CPR for refractory out-of-hospital cardiac arrest. N Engl J Med. 2023;388(4):299-30. The INCEPTION trial*
  - **Objective**
    - The INCEPTION trial was performed to compare the effect of extracorporeal CPR as with conventional CPR on survival with a favorable neurologic outcome at 30 days, in patients with refractory out-of-hospital cardiac arrest and an initial ventricular arrhythmia
  - **Methods**
    - Multicenter, randomized trial from May 2017 – February 2021
    - Location: 10 Centers in the Netherlands
    - Patients - Included
      - Adults aged 18-70 years of age
      - Witnessed arrest
      - Initial ventricular arrhythmia (VT or VF)
      - Refractory cardiac arrest defined as > 15 minutes of ALS

- **Procedures**
  - At the 15-minute mark of ACLS, patients were screened for inclusion/exclusion criteria, the local hospital was notified, patients were packaged and transported to the nearest hospital.
  - After notification of the incoming patient, patients underwent a 1:1 permuted block randomization.
    - EMS teams were unaware of the trial-group assignment
    - If the patient had ROSC prior to cannulation, they remained in the assigned group for the intention to treat analysis.
  - Post-resuscitation care included:
    - TTM at all sites
    - Locally determined post-arrest care (no post-arrest care protocol)
- **Primary outcome**
  - Survival with favorable neurologic outcome (CPC score of 1 or 2) at 30 days
- **Secondary Outcomes**
  - Duration of CPR before ROSC
  - Total duration of CPR
  - ICU days
  - Hospital Days
  - Duration of mechanical ventilation
  - Long-term outcomes: 30d survival, 6-month survival, 6-month neurologic outcome
- **Results**
  - Enrolled a total of 160 patients, 26 were excluded
    - ECPR: 70 patients randomized to ECPR (of which only 52 patients were attempted to ECMO, 46 patients were successfully started on ECMO)
    - Conventional CPR: 64 patients
  - Primary Outcome
    - No difference in 30d survival with favorable neuro outcome: ECPR: 14/70 (20%) vs. C-CPR: 10/62 (16%) *p=0.52*
  - Secondary Outcomes
    - No differences in 3-month or 6-month outcomes
- **Limitations**
  - Lack of standardized protocols for ECPR at different institutions
  - LARGE variation in cannulation times, procedural success rates, and care between 10 institutions.
  - Some participating centers were building their ECPR program while still participating in the INCEPTION Trial. Several centers had never done ECPR prior to participating in INCEPTION. In fact, 4 centers enrolled 2 patients or less.
- **Take Home Points**
  - ECPR is not a cure for cardiac arrest, but is a potential therapy for the right patient to serve as a bridge to recovery or another definitive step to reverse their critical illness
  - Experience in taking care of these patients is critical, the INCEPTION trial may have just shown us that ECPR is not a generalizable approach to cardiac arrest care

Post-Cardiac Arrest

- *Eastwood G, Nichol AD, Hodgson C, et al. Mild hypercapnia or normocapnia after out-of-hospital cardiac arrest. N Engl J Med. 2023. The TAME Trial*
    - **Objective**
        - To test the hypothesis that targeted mild hypercapnia improves neurologic outcomes at 6 months compared with targeted normocapnia in adults with coma following ROSC from OHCA.
    - **Methods**
        - International, investigator-initiated, open-label, randomized trial
        - Patients - Inclusion criteria
            - Adults aged $\geq$ 18 years old
            - Sustained ROSC ($\geq$ 20 min) following OHCA
            - Presumed cardiac or unknown cause
        - Intervention
            - Randomized 1:1 to targeted mild hypercapnia or targeted normocapnia
            - Targeted mild hypercapnia: 50-55 mm Hg
            - Targeted normocapnia: 35-45 mm Hg
            - RASS target of -4 for sedation
            - Used ABGs and ETCO2 to guide ventilation during intervention period
        - Primary outcome
            - Favorable neurologic outcome (Glasgow Outcome Scale – Extended score of 5-8 at 6 months
        - Secondary Outcomes
            - Death within 6 months
            - Poor functional outcome at 6 months (mRS of 4-6)
    - **Results**
        - 1700 patients from 63 ICUs in 17 countries
            - Targeted mild hypercapnia: 847 patients
            - Targeted normocapnia: 853 patients
        - Primary Outcome – Favorable Neurologic Outcome at 6 months
            - Targeted mild hypercapnia: 43.5%
            - Targeted normocapnia: 44.6%
        - Secondary Outcomes
            - Death at 6 months
                - Targeted mild hypercapnia: 48.2%
                - Targeted normocapnia: 45.9%
            - Poor functional outcome at 6 months
                - Targeted mild hypercapnia: 53.4%
                - Targeted normocapnia: 51.3%
        - Adverse Events
            - No difference in pneumonia, arrhythmias, sepsis, bleeding, death due to cerebral causes
    - **Limitations**
        - ED and ICU staff not blinded to interventions
        - Mechanical ventilation, concomitant care not specified in protocol
        - Hypercapnia common at randomization and may have attenuated the difference between groups

        - ICP not routinely monitored – number of patients with elevated ICP or cerebral edema unknown
        - Data on primary outcome missing in 7.6% of patients
        - Patients – most with witnessed arrest, bystander CPR, shockable rhythm, large % STEMI
    - **Take Home Point**
        - In comatose adult patients with ROSC after OHCA, targeted mild hypercapnia did not improve 6 month neurologic outcome compared with normocapnia.

- *Branch KRH, Gatewood MO, Kudenchuk PJ, et al. Diagnostic yield, safety, and outcomes of Head-to-pelvis sudden death CT imaging in post arrest care: The CT FIRST cohort study. Resuscitation. 2023.*
    - **Objective**
        - To compare the standard of care alone to the addition of a whole-body CT scan (authors termed a sudden death CT) within 6 hours of hospital arrival.
    - **Methods**
        - Observational study of OHCA patients with ROSC that compared a historical control group (called the SOC-cohort) against a cohort from a previously study published in 2021 in the Academic Emergency Medicine journal.
        - *SOC-cohort:* Received institutional standard of care diagnostic testing, which commonly included post-arrest EKG, head CT, and echo.
        - *CT cohort:* Received standard of care PLUS head-to-pelvis CT
        - Location: Both cohorts of patients were cared for at 2 academic hospitals in the Seattle Washington area
        - Patients **-** Inclusion Criteria
            - Adults aged $\geq$ 18 years old
            - Successful resuscitation from OHCA without an obvious cause
            - Could undergo the sudden death CT protocol within 6-hours of ROSC
        - Sudden Death CT protocol (included 3 scans)
            - Non-contrast head CT
            - Thoracic CT with an ECG-gated a coronary angiogram
            - Venous phase, non-ECG gated abdomen and pelvis
    - **Primary outcome**
        - The diagnostic yield of the Sudden Death CT protocol compared to the standard of care to identify the cause for the OHCA event.
    - **Secondary Outcomes:**
        - Time to adjudicated OHCA cause
        - Diagnosis of a time critical diagnoses by SDCT compared to standard of care
        - Incidence of delayed diagnosis to time critical diagnosis (> 6 hrs)
        - Safety measurements after SDCT scan (AKI by 48 hours, allergic reactions, or CT complications such as extravasation, unintentional extubation, etc.)
    - **Results**
        - Patients
            - 247 total patients were included in the study
                - SOC cohort: 143
                - SDCT cohort: 104
        - Primary outcome

        - The combination of SDCT and the SOC identified 92% of presumptive causes for OHCA compared to 75% of patients by SOC alone (p: < 0.001).
    - Secondary Outcomes
        - The SDCT protocol was associated with faster diagnosis (3 hours vs. 14 hours)
        - Decreased incidence of delayed time critical diagnosis (12% in SDCT vs. 62% in SOC)
        - Similar survival to hospital discharge and rates of acute kidney injury
- **Limitations**
    - Lack of randomization
    - A number of the patients in the SOC group received at least 1 type of CT scan
    - Lack of blinding for the adjudicators determining the cause for arrest could have biased the authors.
- **Take Home Point**
    - The sudden death CT protocol added to the post-OHCA standard of care early after ROSC by improving the time and diagnostic ability to determine the cause of OHCA.

<u>Septic Shock</u>

- *Shapiro NI, et al. Early restrictive or liberal fluid management for sepsis-induced hypotension. N Engl J Med. 2023. The CLOVERS Trial.*
    - **Objective**
        - The CLOVERS trial was conducted to compare the effects of a restrictive fluid strategy (with early use of pressors) to a liberal fluid strategy in the first 24 hours of resuscitation in patients with sepsis-induced hypotension.
    - **Methods**
        - Multicenter, randomized, unblinded superiority trial
        - 60 US Centers
        - Patients - Included
            - Adults aged 18 years of age or greater
            - Suspected or confirmed infection (defined as the administration or planned administration of antibiotic agents)
            - Sepsis-induced hypotension (SBP < 100 mm Hg after the administration of greater than or equal to 1 L of IVF)
        - Trial Procedures
            - Randomized in a 1:1 ratio
            - Restrictive Fluid Strategy
                - Prioritized vasopressors as the primary treatment for sepsis-induced hypotension
                - Rescue fluids being permitted for prespecified indications that suggested severe intravascular volume depletion
            - Liberal Fluid Strategy
                - Recommended an initial 2 L IVF infusion, followed by fluid boluses on the basis of clinical triggers (i.e., tachycardia)
                - Rescue vasopressors permitted for prespecified indications
            - Each group was followed for a period of 24 hours
        - Primary Outcome: Death from any cause before discharge home by day 90

        - Secondary Outcomes – 28-day measures
            - Days free from MV
            - Days free from RRT
            - Days free from vasopressors
            - Days out of the ICU
            - Days out of the hospital
    - **Results**
        - Enrolled a total of 1563 patients
            - Restrictive Strategy: 782 patients
            - Liberal Strategy: 781 patients
            - Patients had similar baseline characteristics (volume of IVF, pressors) before randomization
        - Data and Safety Monitoring Board recommended halting the trial for futility at the second interim analysis
        - Primary Outcome
            - Restrictive Strategy: 14%
            - Liberal Strategy: 14.9%
            - No statistical difference
        - Secondary Outcomes
            - No differences in any secondary outcome measures
        - Safety Outcomes
            - Number of serious adverse events was similar in both groups
            - 500 patients received vasopressors via a peripheral IV
                - 3 extravasation events
                - All resolved without intervention
    - **Limitations**
        - Despite high adherence, some patients in the restrictive fluid group received more IVF than was intended, while some patients assigned to the liberal fluid group received lower volumes than intended.
        - There may be important subgroups of patients that may benefit from a particular strategy not assessed in this study.
        - Did not test a group whereby the clinicians received no guidance on therapy.
        - Protocol duration was up to 24 hours and almost exclusively enrolled patients presenting to the ED.
    - **Take Home Point**
        - A restrictive fluid strategy with early initiation of vasopressors did not result in a lower, or higher, mortality before discharge home by day 90 in patients with sepsis-induced hypotension refractory to an initial fluid bolus.

- *Bosch NA, Teja B, Law AC, et al. Comparative Effectiveness of Fludrocortisone and Hydrocortisone vs Hydrocortisone Alone Among Patients with Septic Shock. JAMA Intern Med. 2023.*
    - **Objective**
        - To compare the effectiveness of hydrocortisone-fludrocortisone versus hydrocortisone alone in patients admitted with septic shock.
    - **Methods**

        - Large multicenter observational cohort study using the Premier Healthcare Database from 2016-2020. ~20% US inpatient hospitalizations are included in database.
        - Patients - Included
            - Admitted to ICU or step-down unit with septic shock
            - Received norepinephrine
            - Began hydrocortisone within 3 days of admission
        - Trial procedures
            - Accessed Premier Healthcare Database and searched for ICD-10 septic shock.
            - Used hospital billing data to find treatment assignments hydrocortisone-fludrocortisone vs hydrocortisone alone
            - Study day 0 was initiation of hydrocortisone treatment
        - Primary outcome
            - Composite of hospital death and discharge to hospice
        - Secondary outcomes
            - Hospital death
            - Vasopressor-free days by day 28
            - Hospital-free days by day 28
    - **Results**
        - 88,275 met inclusion criteria
            - 85995 hydrocortisone alone
            - 2280 hydrocortisone-fludrocortisone
        - Primary Outcome - Death or discharge to hospice
            - Hydrocortisone-fludrocortisone: 47.2%
            - Hydrocortisone only: 50.8%
            - Adjusted risk difference -3.7% (95% CI, -4.2 to -3.1 % CI, P < .001) favoring hydrocortisone-fludrocortisone group
            - Risk reduction with added fludrocortisone held true even in subgroup analyses (age, sex, hx CHF, time to corticosteroid initiation)
        - Secondary Outcomes
            - Hospital death
                - Hydrocortisone – fludrocortisone: 39.3%
                - Hydrocortisone only: 42.7%
            - Vasopressor-free days:
                - Hydrocortisone – fludrocortisone: 13.8 days
                - Hydrocortisone only: 12.9 days
            - Hospital-free days: 0.7d (95% CI, 0.6-0.8)
                - Hydrocortisone – fludrocortisone: 8.7 days
                - Hydrocortisone only: 8.4 days
    - **Limitations**
        - Observational study at risk for unmeasured confounders
        - Premier Healthcare database lacks physiologic data and vasopressor doses. Risk for unmeasured confounders.
        - Database only provided data by calendar day and not within the day.
    - **Take Home Points**

- The trial results show that fludrocortisone may decrease mortality, increase vasopressor and hospital free days, and have no measurable impact on patient safety.
- The hydrocortisone and fludrocortisone combination therapy may be considered in this high-risk demographic of patients with septic shock requiring vasopressors.

Severe Pneumonia

- *Dequin PF, Meziani F, Quenot JP, et al. Hydrocortisone in severe community-acquired pneumonia. N Engl J Med. 2023. The CAPE COD Trial.*
  - **Objective**
    - To evaluate whether hydrocortisone administration reduced mortality at 28 days among patients admitted to an intensive care unit (ICU) for severe community-acquired pneumonia.
  - **Methods**
    - Double-blind, Randomized, controlled superiority trial
    - Location: 31 French centers
    - Patients
      - General Inclusion Criteria
        - Adults aged $\geq$ 18 years old
        - Diagnosis of pneumonia with clinical and radiographic criteria
        - Severe pneumonia defined by requiring 1 or 4 criteria:
          - Mechanical Ventilation (invasive or noninvasive)
          - HFNC with a FiO2 $\geq$ 50% and PaO2:FiO2 ratio < 300
          - Non-rebreather mask with PaO2:FiO2 ratio < 300
          - Pneumonia severity index (PSI) > 130
        - Able to be randomized/receive allocated treatment within 24h of onset of severity criteria
    - Trial Procedures
      - All patients received usual care for pneumonia (antibiotics, provider determined respiratory support)
      - Randomized 1:1 to either control or intervention
        - Control Group: received a blinded injection of placebo (saline) according to the same regimen used in the hydrocortisone group
        - Hydrocortisone Group: Received hydrocortisone treatment where dose/duration was *determined on Day 4* by predefined discontinuation criteria
    - Primary outcome
      - Survival with favorable neurologic outcome (CPC 1 or 2) at 30 days
    - Secondary Outcomes:
      - Clinical outcomes: 90d mortality, patients not progressing to mechanical ventilation, 28d incidence of endotracheal intubation initiation, 28d incidence of vasopressor initiation
      - Adverse Events**:** 28d incidence of hospital acquired infection, VAP, blood stream infection, GI Bleed, insulin requirements for hyperglycemia, weight change through hospital day 7.

- **Results**
  - 795 patients included in final analysis
    - 400 received hydrocortisone
    - 395 received placebo
  - Demographics were well matched, as expected
    - Most patients (>80%) had a PSI score of 4 or 5 (highest)
    - Respiratory support:
      - HFNC: 42%
      - NIV: 22%
      - Invasive MV: ~ 22%
      - NRB: 14%
  - Primary Outcome: Hydrocortisone treatment decreased Death at 28d
    - Hydrocortisone: 6.2%
    - Placebo: 11.9%
    - *P-value: 0.006*
  - Secondary Outcomes
    - No differences in secondary clinical outcomes
    - Adverse events: higher cumulative insulin requirement in the hydrocortisone group
  - Pre-defined subgroups that may benefit from hydrocortisone (worth warning that these are really small numbers, so could be due to random chance)
    - Patients not requiring mechanical ventilation
    - Women
    - High PSI score > 130
    - Age > 65
- **Limitations Identified by the Authors**
  - The observed mortality was much lower in the control group (11.9%) than expected (27%), indicating a lower severity of illness
- **Take Home Point**
  - Hydrocortisone decreased 28-day mortality for patients with severe CAP admitted to the ICU.

Procedures

- *van Baarle FLF, et al. Platelet transfusion before CVC placement in patients with thrombocytopenia. N Engl J Med. 2023; 388:1956-65. The PACER Trial.*
  - **Objective**
    - To evaluate the hypothesis that the omission of prophylactic platelet transfusion before CVC placement in patients with platelets of 10,000-50,000 would not increase the risk of catheter-related bleeding.
  - **Methods**
    - A multicenter, randomized, controlled, noninferiority trial
    - Conducted at 10 hospitals in the Netherlands (7 academic, 3 general) from Feb 2016-March 2022 – conducted in the ICU and on the hematology unit
    - Patients
      - All CVC procedures in patients with platelets of 10,000-50,000 within 24 hours of the procedure
    - Trial Procedures

- Patients were randomly assigned in a 1:1 ratio to either receive 1 unit of platelets before CVC placement or not.
- Required CVC placement using US by an experience operator (had to have performed at least 50 US-guided CVC placements)
- CVCs could be either tunneled or nontunneled.
- Could be placed in the IJ, subclavian, or femoral veins.

- Primary outcome
  - Occurrence of catheter-related bleeding of grade 2 to 4 within 24 hours of placement.
    - Grade 0: no bleeding
    - Grade 1: oozing, hematoma; bleeding that resulted in < 20 min of manual compression to stop
    - Grade 2: needed minor intervention to stop such as compression for > 20 min
    - Grade 3: needed radiologic or elective operative intervention or red cell transfusion but maintained HD stability
    - Grade 4: associated with severe HD instability
- Secondary outcomes
  - Major bleeding (Grades 3 or 4)
  - Platelet and red cell transfusions within 24 hours after CVC placement
  - Allergic reactions within 24 hours
  - Onset of ALI within 48 hours after placement
  - ICU and hospital LOS
  - In-hospital mortality
  - Financial costs

- **Results**
  - In total, 393 CVC placements involving 358 patients were included.
  - **Ultimately, 373 were included in the final analysis**
    - Characteristics of patients were well balanced between the groups
    - A total of 15 adverse events were observed, with 13 of these categorized as serious
  - Primary Outcome - Grade 2 to 4 catheter-related bleeding
    - Transfusion group: 4.8%
    - No-Transfusion group: 11.9%
    - Noninferiority was not shown
  - Secondary Outcomes
    - No Grade 4 bleeding complications occurred.
    - Risk of Grade 3 or 4 CVC-related bleeding
      - Transfusion group: 2.1%
      - No-Transfusion group: 4.9%
    - No-transfusion group received more platelet transfusions in the 24 hours after CVC placement
    - ICU LOS was slight shorter in the no-transfusion group
    - Mortality was similar between the groups.
    - The bleeding risk among patients being treated on the hematology ward was higher than that among patients in the ICU.

        - The bleeding risk was also higher with the use of tunneled catheters compared to nontunneled CVCs.
    - Cost
        - Overall costs related to transfusion and bleeding events were higher in the transfusion group (by about $410), driven mainly by the up-front cost of prophylactic platelet transfusion.
        - However, transfusion costs in the 24 hours after CVC placement were higher in the no-transfusion group – due to higher frequency of platelet and red cell transfusions.
- **Limitations Identified by Authors**
    - Conducted only in the Netherlands
    - Required US guidance – may not be available in all settings
    - Single-blind trial
    - Clinical relevance of Grade 2 bleeding?
- **Take Home Points**
    - In patients with severe thrombocytopenia, withholding prophylactic platelet transfusion before CVC placement in those with a platelet count of 10,000-50,000 resulted in more CVC-related bleeding than prophylactic platelet transfusion.
    - Authors advocate for a personalized approach
        - Consider prophylactic transfusion in patients with platelet counts < 30,000 especially on a hematology ward
        - For patients in the ICU, consider a no-transfusion strategy with intensive monitoring and a low threshold for therapeutic use of blood products.

Trauma

- *Jansen JO, et al. Emergency department resuscitative endovascular balloon occlusion of the aorta in trauma patients with exsanguinating hemorrhage. The UK-REBOA Randomized Clinical Trial. JAMA. 2023; published online October 12, 2023.*
    - **Objective**
        - To examine the effectiveness of REBOA and standard care compared to standard care alone for the management of uncontrolled hemorrhage.
    - **Methods**
        - Multicenter, open label, Bayesian, group-sequential, registry-enabled, randomized clinical trial.
        - 16 major trauma centers in the UK
        - Patients
            - Inclusion criteria
                - Adults aged $\geq$ 16 years
                - Presented to major trauma centers in the UK.
                - Confirmed or suspected life-threatening torso hemorrhage deemed amenable to REBOA.
        - Intervention
            - Randomized 1:1 to either REBOA with standard care or standard care alone.
            - REBOA with standard care

        - Clinicians using REBOA were required to complete the trial's training package.
        - Trial did not prescribe or mandate a particular REBOA product.
        - Level of occlusion (Zone I or Zone III) left to the judgment of the attending physician.
    - Standard care alone
        - Patients received expected care that is provided at major trauma center – intubation, balanced blood product transfusion, early operative or endovascular hemorrhage control.
        - Could also include open aortic occlusion.
- Primary outcome
    - All-cause mortality at 90 days
- Secondary Outcomes
    - Mortality at 6 months, in-hospital, 24 hours, 6 hours, or 3 hours
    - Need for definitive hemorrhage control procedures.
    - Time to commencement of definitive hemorrhage control procedures
    - Complications
    - Length of stay
    - Blood product use
    - Cause of death

- **Results**
    - 90 patients enrolled.
        - REBOA with standard care: 46 patients
        - Standard care: 44 patients
    - Treatment Pathways for REBOA
        - 46 patients who received REBOA with standard care.
            - 19 (41%) had REBOA inserted and inflated
            - 17 (37%) responded to other resuscitative efforts and REBOA not needed
            - 2 (4%) deteriorated before arterial access could be established
            - 8 (17%) where arterial access could not be established
        - Zone I inflation: 10 patients (53%)
        - Zone III inflation: 9 patients (47%)
        - Median time from arrival to REBOA inflation: 32 min
        - Median duration of REBOA inflation: 29 min
    - Primary Outcome – All-cause 90-day mortality
        - REBOA with standard care: 54%
        - Standard care: 42%
        - OR mortality at 90 days for REBOA with standard care: 1.58
    - Secondary Outcomes
        - ORs for mortality at 6 months, in-hospital, 24, 6, and 3 hours all increased for REBOA with standard care.
        - More deaths due to bleeding in the REBOA and standard care group – most deaths occurred within 24 hours and most within 3 hours.
        - Median time from randomization to definitive hemorrhage control was 19 min longer in the REBOA and standard care group.

- **Limitations Identified by the Authors**
  - Trial has an overall small size.
  - Trial performed in the UK where blunt trauma predominates – may not be generalizable.
  - Low proportion of patients actually had REBOA deployed and inflated.
  - Some baseline differences between the groups
  - Mortality in the current trial higher than other studies of hemorrhage control interventions
- **Take Home Point**
  - REBOA with standard care in trauma patients with exsanguinating hemorrhage did not reduce 90-day all-cause mortality compared with standard care alone.