Background:

The incidence of major traumatic vascular injury is increasing in the United States and accounts for up to 20% of all traumatic deaths. Following resuscitation and hemorrhage control, restoration of vascular continuity is a critical priority. Temporary intravascular shunts (TIVS) allow restoration of vascular continuity in situations when it is not possible or practical at the index operation to perform a definitive repair either due to hemodynamic and physiologic instability, massive contamination, complex orthopedic injuries, or lack of resources at the treating facility. The use of TIVS by the military during the recent wars in Iraq and Afghanistan was part of the innovations resulting in a 5-10 fold decrease in early extremity amputation rates compared with previous conflicts (Gifford, 2009). With the incidence of major vascular trauma increasing in the United States, translation of this important military experience into civilian practice is critical.

The military data on TIVS show that, under combat conditions, potential complications from TIV shunts including disruption with hemorrhage, infections, intimal hyperplasia with early loss of vascular repairs are rare and that patients undergoing temporary vascular shunting do not have worse outcomes than those with initial definitive repair or ligation with a trend toward improved outcomes. (Gifford, 2009). Previous retrospective studies in the civilian literature have also been conducted. Subramanian et al looked at 67 patients treated with temporary shunting. They showed an 88% overall survival and 73% limb salvage rate (Submaranian, 2008). Inaba et al conducted a multicenter retrospective analysis from 7 level one trauma centers over 9 years. This study contained 213 injuries treated with TIVS and demonstrated a 79% overall survival and 81% survival to definitive vascular repair. Overall, this group reported that 5.6% of shunts thrombosed, and 1.4% dislodged prior to definitive vascular repair. They were not able to independently identify any variables associated with shunt complications, however and did not note a difference in complications between shunts in place less than 6 hours as compared to those in place longer (Inaba, 2016). We have recently published (in press) retrospective data from our institution which shows that shunts in place for longer than 6 hours have greater shunt related complications defined as shunt dislodgement,

thrombosis or distal ischemia (Matthew, 2016). Given the retrospective nature of that study however, exact shunt dwell times and other vital parameters were unable to be fully analyzed.

The military experience and current civilian literature provide some guidance in the best use of TIVS however; there is still insufficient evidence available to provide sound, evidence-based guidelines for their ideal clinical application. By prospectively assessing variables related to TIVS outcomes in a multicenter approach, we hope to gain a better understanding as how to best optimize outcomes in critically injured patients with major vascular injuries. We hypothesize that TIVS in place for longer than 6 hours are associated with more shunt related complications.

Primary Aim: To determine the effect of shunt dwell time on shunt related outcomes after major arterial injury

Secondary Aims:

1. To determine whether a shunt dwell period of >6 hours is a reliable clinical cut-point that is associated with an increase in shunt related complications.
2. **To** determine the impact that clinical variables including shunt size and location, hypotension during the shunt dwell period, the use of systemic anticoagulation, venous injury management, and the performance of fasciotomies have on shunt-related outcomes.

Inclusion Criteria: All patients 15 years of age or older undergoing placement of a TIVS following traumatic arterial injury will be included.

Exclusion criteria: Death prior to shunt removal, TIVS placed for injuries distal to the popliteal or brachial artery.

The primary outcome will be shunt complications defined as shunt dislodgement, thrombosis or distal organ ischemia.

Secondary outcomes: Mortality, limb salvage, disposition, hospital length of stay, ICU length of stay.

Data Collection and Statistical Analysis: Standardized data will be collected for each patient (see Data Collection Tool, Appendix A and Data Dictionary, Appendix B). Risk factors for TIVS related complications will be assessed using univariate and multivariate analysis. Continuous variables will be compared using Student's t-test and the Mann Whitney U test. The Chi-squared tests or Fisher's exact test will be used to compare categorical variables. All variables with a p value <0.2 on univariate analysis will be entered into a multivariable logistic regression analysis to identify independent risk factors for temporary intravascular shunt related complications. Data will be reported as adjusted odds ratios with 95 % confidence intervals. Statistical significance will be set at a $p<0.05$.

Sample size calculations: Our previous data shows a zero percent incidence of shunt related complications in patients with shunts in place for less than six hours. In patients with shunts in place for greater than 6 hours, the incidence of complications was 30%. This equates to a sample size calculation of 56 patients for 90% power and a p value of 0.05. Given that previous civilian retrospective studies have reported lower rates of complications overall (Inaba, 2016), we propose to power this study for an effect size of 15%. With an 80% power, this will require accrual of 94 patients.

Management of Information for Multi-Center Research: Patients will be given a deidentified study number for data recording purposes. No personally identifying information will be collected or stored on any patient in the study. Data will be managed using a secure REDcap database. This database will only be accessible by approved study personnel. All communication regarding protocol modifications will be coordinated by the study PI at the University of Pennsylvania. Since this is an observational study only, the main risk to patients is a breach of confidentiality. If there are any unanticipated problems involving risks to participants or others, communication and reporting would be handled by the study PI at the University of Pennsylvania. Any reporting of interim results would be performed by the study investigators at the University of Pennsylvania.

Consent Procedures: This is a prospective observational study, designed to prospectively record data on patients who are managed according to institutional patient management protocols. Thus, waiver of informed consent is requested. Data will be recorded on a data sheet and transferred to a secured database that is devoid of patient identifiers. Only authorized study personnel will have access to the secure database. Datasheets will be kept in a locked file cabinet that only authorized study personnel may access.

R**isk/ Benefit Analysis:** Institutional Review Board approval will be obtained at all institutions and data use agreements will be obtained when required. This is a prospective observational study designed to record data on patients managed according to institutional patient management protocols. There is no intervention conducted in this trial therefore the greatest risk involved in participating is a breach of confidentiality. This risk will be minimized by deidentifying all patient information and storing all study data on a secure password protected server that is only accessible by authorized study personnel.

Study Timeline:

Primary Site IRB approval: 2/2017

Study initiation: 2/2017

Data Collection: 2/2017 – 6/2018

Study Closure and Data Analysis: 6/2018

Abstract Submission for EAST Annual Conference: 7/2018

References:

The use of temporary vascular shunts as a damage control adjunct in the management of wartime vascular injury.
Rasmussen TE, Clouse WD, Jenkins DH, Peck MA, Eliason JL, Smith DL. J Trauma. 2006 Jul;61(1):8-12

Effect of temporary shunting on extremity vascular injury: an outcome analysis from the Global War on Terror vascular injury initiative.
Gifford SM, Aidinian G, Clouse WD, Fox CJ, Porras CA, Jones WT, Zarzabal LA, Michalek JE, Propper BW, Burkhardt GE, Rasmussen TE. J Vasc Surg. 2009 Sep;50(3):549-55

Temporary Arterial Shunts in Damage Control: Experience and Outcomes
Matthew S, Smith B, Cannon J, Reilly P, Schwab CW, Seamon MJ. J Trauma Acute Care Surg. 2016 Dec 23

Multicenter evaluation of temporary intravascular shunt use in vascular trauma.
Inaba K, Aksoy H, Seamon MJ, Marks JA, Duchesne J, Schroll R, Fox CJ, Pieracci FM, Moore EE, Joseph B, Haider AA, Harvin JA, Lawless RA, Cannon J, Holland SR, Demetriades D; Multicenter Shunt Study Group. J Trauma Acute Care Surg. 2016 Mar;80(3):359-64

A decade's experience with temporary intravascular shunts at a civilian level I trauma center.
Subramanian A, Vercruysse G, Dente C, Wyrzykowski A, King E, Feliciano DV. J Trauma Acute Care Surg. 2008 Aug;65(2):316-24