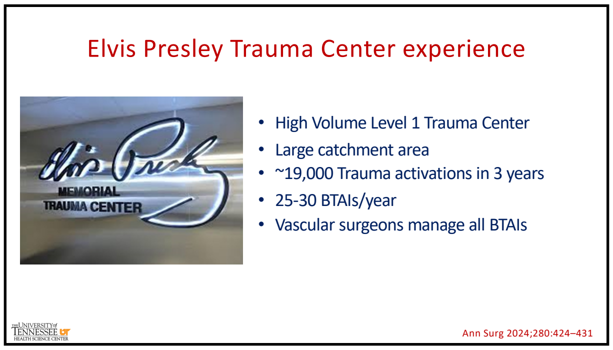
Traumatic Thoracic Aortic Coarctation after Blunt Thoracic Aortic Injury

Erica L. Mitchell MD, EdM SE, DFSVS, FACS, MAMSE
Professor & Chief, Vascular and Endovascular Surgery
University of Tennessee Health & Science University
Regional One Health, Elvis Presley Trauma Center

Regional One Health

THE UNIVERSITY of TENNESSEE HEALTH SCIENCE CENTER

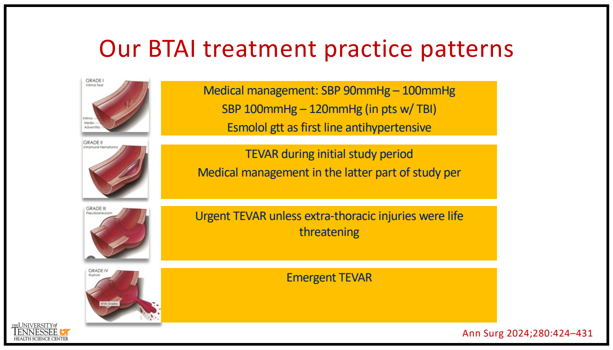
Disclosures



Elvis Presley Trauma Center experience

- High Volume Level 1 Trauma Center
- Large catchment area
- ~19,000 Trauma activations in 3 years
- 25-30 BTAIs/year
- Vascular surgeons manage all BTAIs

Ann Surg 2024;280:424–431



Our BTAI treatment practice patterns

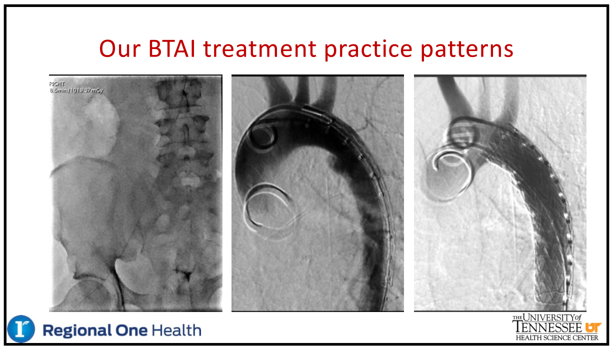
Medical management: SBP 90mmHg – 100mmHg
SBP 100mmHg – 120mmHg (in pts w/ TBI)
Esmolol gtt as first line antihypertensive

TEVAR during initial study period
Medical management in the latter part of study per

Urgent TEVAR unless extra-thoracic injuries were life threatening

Emergent TEVAR

Ann Surg 2024;280:424–431

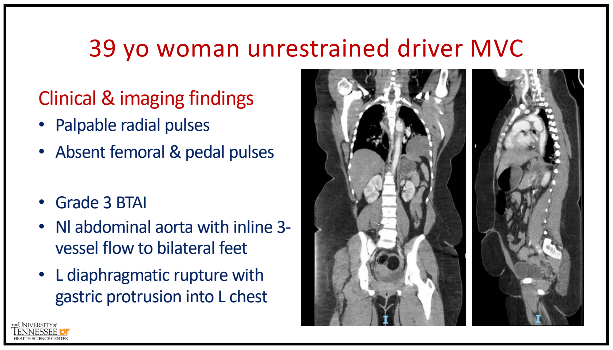


Our BTAI treatment practice patterns

Regional One Health

THE UNIVERSITY of TENNESSEE HEALTH SCIENCE CENTER

Everything was going smoothly……

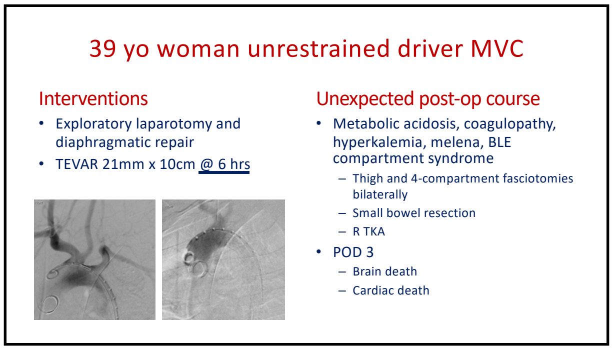


39 yo woman unrestrained driver MVC

Clinical & imaging findings

- Palpable radial pulses
- Absent femoral & pedal pulses

- Grade 3 BTAI
- Nl abdominal aorta with inline 3-vessel flow to bilateral feet
- L diaphragmatic rupture with gastric protrusion into L chest



39 yo woman unrestrained driver MVC

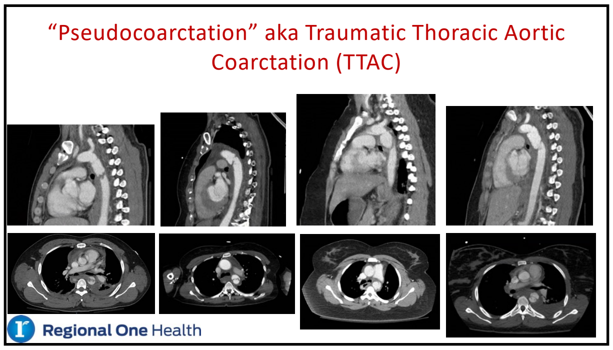
Interventions

- Exploratory laparotomy and diaphragmatic repair
- TEVAR 21mm x 10cm @ 6 hrs

Unexpected post-op course

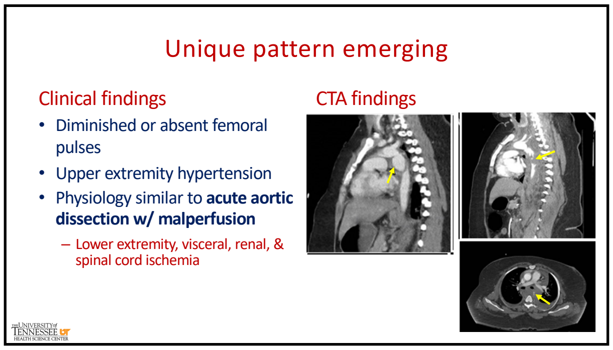
- Metabolic acidosis, coagulopathy, hyperkalemia, melena, BLE compartment syndrome
  - Thigh and 4-compartment fasciotomies bilaterally
  - Small bowel resection
  - R TKA
- POD 3
  - Brain death
  - Cardiac death

Emerging pattern of injuries



"Pseudocoarctation" aka Traumatic Thoracic Aortic Coarctation (TTAC)

Regional One Health

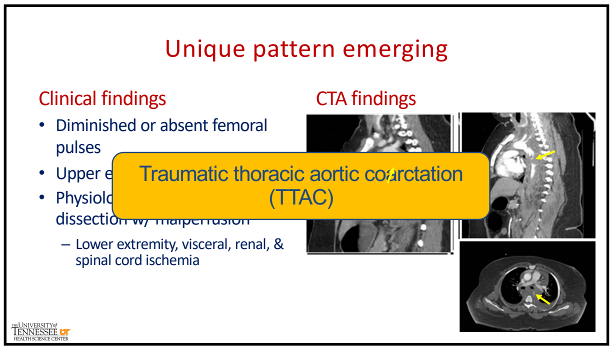


Unique pattern emerging

Clinical findings

- Diminished or absent femoral pulses
- Upper extremity hypertension
- Physiology similar to **acute aortic dissection w/ malperfusion**
  - Lower extremity, visceral, renal, & spinal cord ischemia

CTA findings



Unique pattern emerging

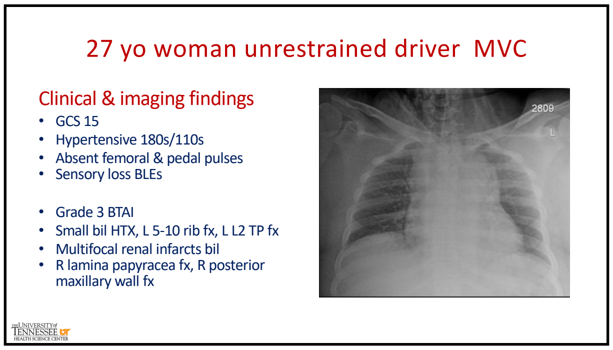
Clinical findings

- Diminished or absent femoral pulses
- Upper e
- Physiolo dissection w/ malperfusion
  - Lower extremity, visceral, renal, & spinal cord ischemia

CTA findings

Traumatic thoracic aortic coarctation (TTAC)

Changed our approach to managing these injuries

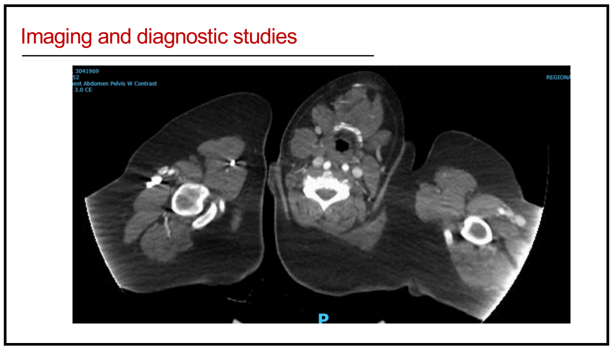


27 yo woman unrestrained driver MVC

Clinical & imaging findings

- GCS 15
- Hypertensive 180s/110s
- Absent femoral & pedal pulses
- Sensory loss BLEs

- Grade 3 BTAI
- Small bil HTX, L 5-10 rib fx, L L2 TP fx
- Multifocal renal infarcts bil
- R lamina papyracea fx, R posterior maxillary wall fx

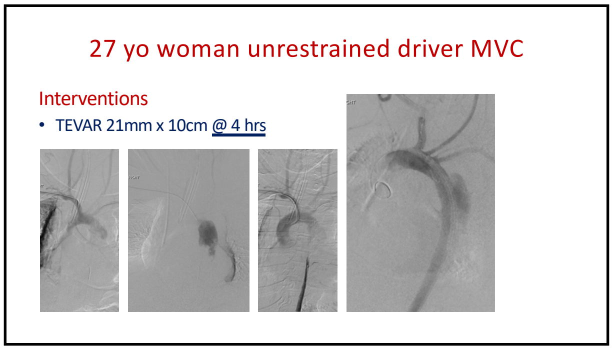


Imaging and diagnostic studies

27 yo woman unrestrained driver MVC

Interventions

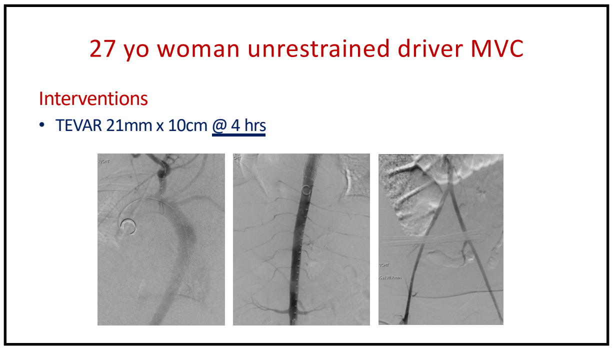
- TEVAR 21mm x 10cm @ 4 hrs



27 yo woman unrestrained driver MVC

Interventions

- TEVAR 21mm x 10cm @ 4 hrs



27 yo woman unrestrained driver MVC

Interventions

- TEVAR 21mm x 10cm @ 4 hrs

27 yo woman unrestrained driver MVC

Interventions

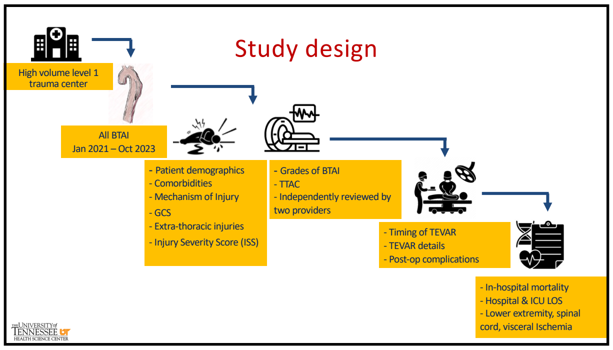
- TEVAR 21mm x 10cm @ 4 hrs

Unexpected post-op course

- HR 120-130's sBP50-60's levophed 20mcg/min
- ABG 6.92 BD -19, lactate 7.6-13.8, K 6.1 H/H 7.4/25 INR 1.8
- RX- 2 amp bicarb and gtt, vasopression gtt
- Profoundly hypotensive, tachy and lost pulse
- CT bil, 250cc L CT
- ACLS with brief return of ROSC
- Ex-lap- all SB and colon ischemic
- ACLS
- Patient death

Confirm trends and outcomes

Study design



High volume level 1 trauma center

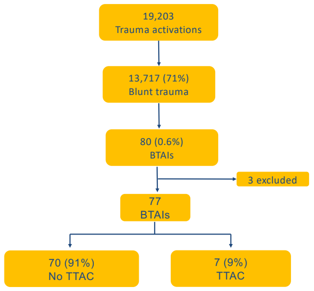
All BTAI
Jan 2021 – Oct 2023

- Patient demographics
- Comorbidities
- Mechanism of Injury
- GCS
- Extra-thoracic injuries
- Injury Severity Score (ISS)

- Grades of BTAI
- TTAC
- Independently reviewed by two providers

- Timing of TEVAR
- TEVAR details
- Post-op complications

- In-hospital mortality
- Hospital & ICU LOS
- Lower extremity, spinal cord, visceral Ischemia



19,203
Trauma activations

13,717 (71%)
Blunt trauma

80 (0.6%)
BTAIs

3 excluded

77
BTAIs

70 (91%)
No TTAC

7 (9%)
TTAC

Study population
77 patients

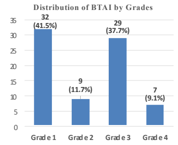
67.5% male

40 yrs

ISS 29

19%
Traumatic brain injuries

19%
Solid organ injuries



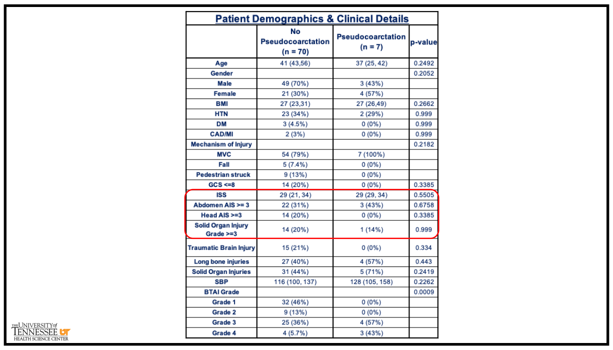
Medical management alone
45%

TEVAR
55%

No retrograde type A dissections
No conversion to open
No type 1a or 1B endoleaks
3 (7.1%) type 2 endoleak

Patient Demographics & Clinical Details

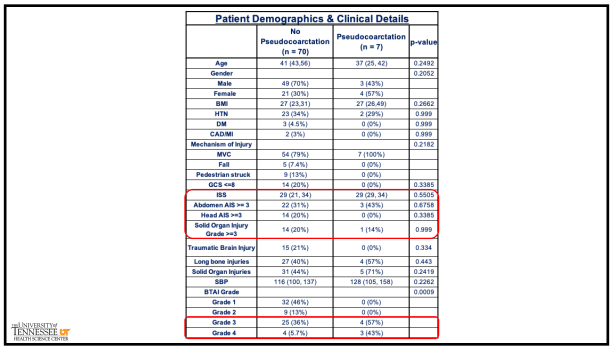
	No Pseudocoarctation (n = 70)	Pseudocoarctation (n = 7)	p-value
Age	41 (43,56)	37 (25, 42)	0.2492
Gender			0.2052
Male	49 (70%)	3 (43%)	
Female	21 (30%)	4 (57%)	
BMI	27 (23,31)	27 (26,49)	0.2662
HTN	23 (34%)	2 (29%)	0.999
DM	3 (4.5%)	0 (0%)	0.999
CAD/MI	2 (3%)	0 (0%)	0.999
Mechanism of Injury			0.2182
MVC	54 (79%)	7 (100%)	
Fall	5 (7.4%)	0 (0%)	
Pedestrian struck	9 (13%)	0 (0%)	
GCS <=8	14 (20%)	0 (0%)	0.3385
ISS	29 (21, 34)	29 (29, 34)	0.5505
Abdomen AIS >= 3	22 (31%)	3 (43%)	0.6758
Head AIS >=3	14 (20%)	0 (0%)	0.3385
Solid Organ Injury Grade >=3	14 (20%)	1 (14%)	0.999
Traumatic Brain Injury	15 (21%)	0 (0%)	0.334
Long bone injuries	27 (40%)	4 (57%)	0.443
Solid Organ Injuries	31 (44%)	5 (71%)	0.2419
SBP	116 (100, 137)	128 (105, 158)	0.2262
BTAI Grade			0.0009
Grade 1	32 (46%)	0 (0%)	
Grade 2	9 (13%)	0 (0%)	
Grade 3	25 (36%)	4 (57%)	
Grade 4	4 (5.7%)	3 (43%)	



Patient Demographics & Clinical Details

	No Pseudocoarctation (n = 70)	Pseudocoarctation (n = 7)	p-value
Age	41 (43,56)	37 (25, 42)	0.2492
Gender			0.2052
Male	49 (70%)	3 (43%)	
Female	21 (30%)	4 (57%)	
BMI	27 (23,31)	27 (26,49)	0.2662
HTN	23 (34%)	2 (29%)	0.999
DM	3 (4.5%)	0 (0%)	0.999
CAD/MI	2 (3%)	0 (0%)	0.999
Mechanism of Injury			0.2182
MVC	54 (79%)	7 (100%)	
Fall	5 (7.4%)	0 (0%)	
Pedestrian struck	9 (13%)	0 (0%)	
GCS <=8	14 (20%)	0 (0%)	0.3385
ISS	29 (21, 34)	29 (29, 34)	0.5505
Abdomen AIS >= 3	22 (31%)	3 (43%)	0.6758
Head AIS >=3	14 (20%)	0 (0%)	0.3385
Solid Organ Injury Grade >=3	14 (20%)	1 (14%)	0.999
Traumatic Brain Injury	15 (21%)	0 (0%)	0.334
Long bone injuries	27 (40%)	4 (57%)	0.443
Solid Organ Injuries	31 (44%)	5 (71%)	0.2419
SBP	116 (100, 137)	128 (105, 158)	0.2262
BTAI Grade			0.0009
Grade 1	32 (46%)	0 (0%)	
Grade 2	9 (13%)	0 (0%)	
Grade 3	25 (36%)	4 (57%)	
Grade 4	4 (5.7%)	3 (43%)	

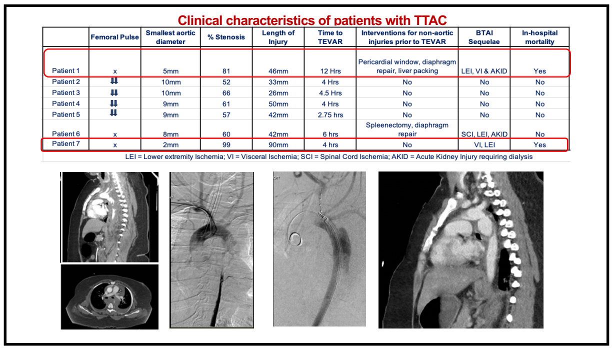
THE UNIVERSITY of TENNESSEE UT
HEALTH SCIENCE CENTER



Patient Demographics & Clinical Details

	No Pseudocoarctation (n = 70)	Pseudocoarctation (n = 7)	p-value
Age	41 (43,56)	37 (25, 42)	0.2492
Gender			0.2052
Male	49 (70%)	3 (43%)	
Female	21 (30%)	4 (57%)	
BMI	27 (23,31)	27 (26,49)	0.2662
HTN	23 (34%)	2 (29%)	0.999
DM	3 (4.5%)	0 (0%)	0.999
CAD/MI	2 (3%)	0 (0%)	0.999
Mechanism of Injury			0.2182
MVC	54 (79%)	7 (100%)	
Fall	5 (7.4%)	0 (0%)	
Pedestrian struck	9 (13%)	0 (0%)	
GCS <=8	14 (20%)	0 (0%)	0.3385
ISS	29 (21, 34)	29 (29, 34)	0.5505
Abdomen AIS >= 3	22 (31%)	3 (43%)	0.6758
Head AIS >=3	14 (20%)	0 (0%)	0.3385
Solid Organ Injury Grade >=3	14 (20%)	1 (14%)	0.999
Traumatic Brain Injury	15 (21%)	0 (0%)	0.334
Long bone injuries	27 (40%)	4 (57%)	0.443
Solid Organ Injuries	31 (44%)	5 (71%)	0.2419
SBP	116 (100, 137)	128 (105, 158)	0.2262
BTAI Grade			0.0009
Grade 1	32 (46%)	0 (0%)	
Grade 2	9 (13%)	0 (0%)	
Grade 3	25 (36%)	4 (57%)	
Grade 4	4 (5.7%)	3 (43%)	

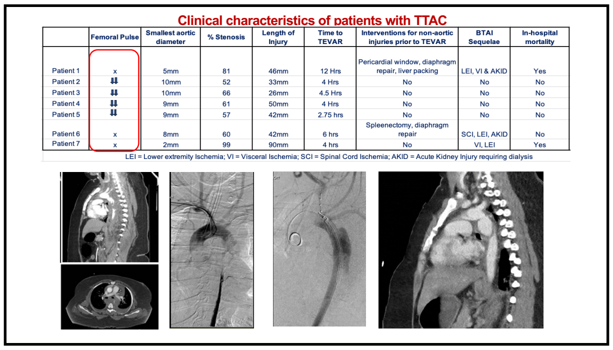
THE UNIVERSITY of TENNESSEE UT
HEALTH SCIENCE CENTER



Clinical characteristics of patients with TTAC

	Femoral Pulse	Smallest aortic diameter	% Stenosis	Length of Injury	Time to TEVAR	Interventions for non-aortic injuries prior to TEVAR	BTAI Sequelae	In-hospital mortality
Patient 1	x	5mm	81	46mm	12 Hrs	Pericardial window, diaphragm repair, liver packing	LEI, VI & AKID	Yes
Patient 2	⇊	10mm	52	33mm	4 Hrs	No	No	No
Patient 3	⇊	10mm	66	26mm	4.5 Hrs	No	No	No
Patient 4	⇊	9mm	61	50mm	4 Hrs	No	No	No
Patient 5	⇊	9mm	57	42mm	2.75 hrs	No	No	No
Patient 6	x	8mm	60	42mm	6 hrs	Spleenectomy, diaphragm repair	SCI, LEI, AKID	No
Patient 7	x	2mm	99	90mm	4 hrs	No	VI, LEI	Yes

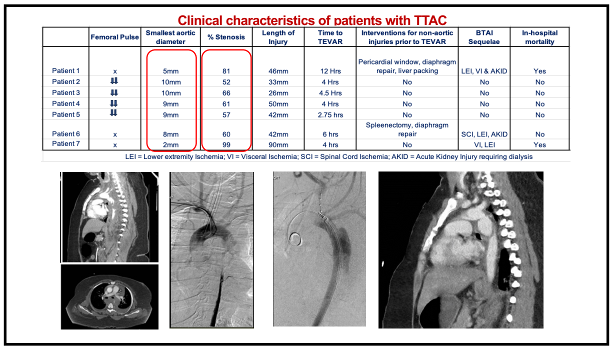
LEI = Lower extremity Ischemia; VI = Visceral Ischemia; SCI = Spinal Cord Ischemia; AKID = Acute Kidney Injury requiring dialysis



Clinical characteristics of patients with TTAC

	Femoral Pulse	Smallest aortic diameter	% Stenosis	Length of Injury	Time to TEVAR	Interventions for non-aortic injuries prior to TEVAR	BTAI Sequelae	In-hospital mortality
Patient 1	x	5mm	81	46mm	12 Hrs	Pericardial window, diaphragm repair, liver packing	LEI, VI & AKID	Yes
Patient 2	⇊	10mm	52	33mm	4 Hrs	No	No	No
Patient 3	⇊	10mm	66	26mm	4.5 Hrs	No	No	No
Patient 4	⇊	9mm	61	50mm	4 Hrs	No	No	No
Patient 5	⇊	9mm	57	42mm	2.75 hrs	No	No	No
Patient 6	x	8mm	60	42mm	6 hrs	Spleenectomy, diaphragm repair	SCI, LEI, AKID	No
Patient 7	x	2mm	99	90mm	4 hrs	No	VI, LEI	Yes

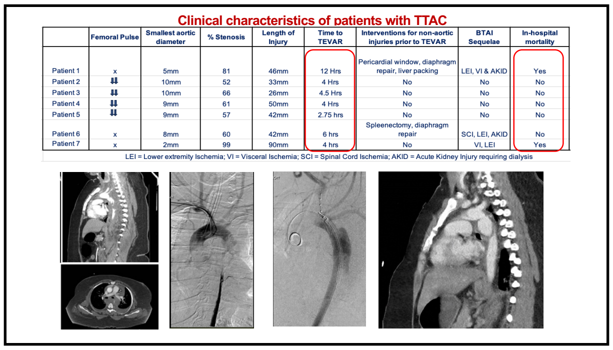
LEI = Lower extremity Ischemia; VI = Visceral Ischemia; SCI = Spinal Cord Ischemia; AKID = Acute Kidney Injury requiring dialysis



Clinical characteristics of patients with TTAC

	Femoral Pulse	Smallest aortic diameter	% Stenosis	Length of Injury	Time to TEVAR	Interventions for non-aortic injuries prior to TEVAR	BTAI Sequelae	In-hospital mortality
Patient 1	x	5mm	81	46mm	12 Hrs	Pericardial window, diaphragm repair, liver packing	LEI, VI & AKID	Yes
Patient 2	⇊	10mm	52	33mm	4 Hrs	No	No	No
Patient 3	⇊	10mm	66	26mm	4.5 Hrs	No	No	No
Patient 4	⇊	9mm	61	50mm	4 Hrs	No	No	No
Patient 5	⇊	9mm	57	42mm	2.75 hrs	No	No	No
Patient 6	x	8mm	60	42mm	6 hrs	Spleenectomy, diaphragm repair	SCI, LEI, AKID	No
Patient 7	x	2mm	99	90mm	4 hrs	No	VI, LEI	Yes

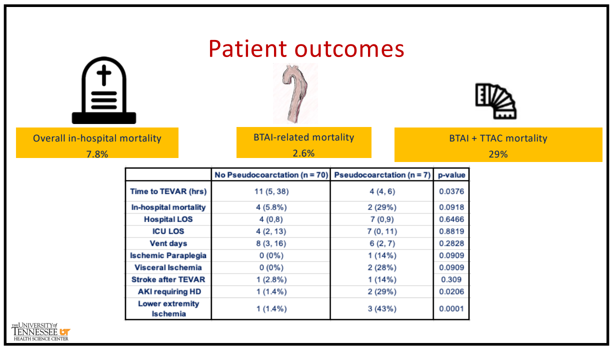
LEI = Lower extremity Ischemia; VI = Visceral Ischemia; SCI = Spinal Cord Ischemia; AKID = Acute Kidney Injury requiring dialysis



Clinical characteristics of patients with TTAC

	Femoral Pulse	Smallest aortic diameter	% Stenosis	Length of Injury	Time to TEVAR	Interventions for non-aortic injuries prior to TEVAR	BTAI Sequelae	In-hospital mortality
Patient 1	x	5mm	81	46mm	12 Hrs	Pericardial window, diaphragm repair, liver packing	LEI, VI & AKID	Yes
Patient 2	⇊	10mm	52	33mm	4 Hrs	No	No	No
Patient 3	⇊	10mm	66	26mm	4.5 Hrs	No	No	No
Patient 4	⇊	9mm	61	50mm	4 Hrs	No	No	No
Patient 5	⇊	9mm	57	42mm	2.75 hrs	No	No	No
Patient 6	x	8mm	60	42mm	6 hrs	Spleenectomy, diaphragm repair	SCI, LEI, AKID	No
Patient 7	x	2mm	99	90mm	4 hrs	No	VI, LEI	Yes

LEI = Lower extremity Ischemia; VI = Visceral Ischemia; SCI = Spinal Cord Ischemia; AKID = Acute Kidney Injury requiring dialysis



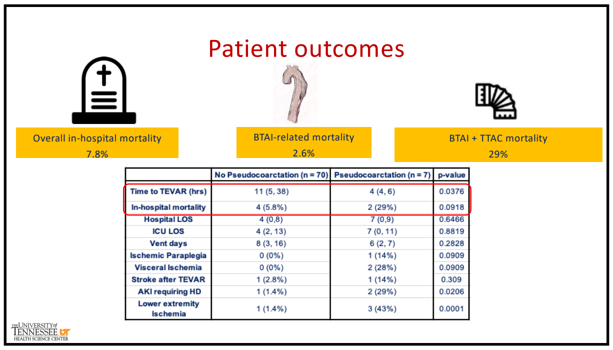
Patient outcomes

Overall in-hospital mortality
7.8%

BTAI-related mortality
2.6%

BTAI + TTAC mortality
29%

	No Pseudocoarctation (n = 70)	Pseudocoarctation (n = 7)	p-value
Time to TEVAR (hrs)	11 (5, 38)	4 (4, 6)	0.0376
In-hospital mortality	4 (5.8%)	2 (29%)	0.0918
Hospital LOS	4 (0,8)	7 (0,9)	0.6466
ICU LOS	4 (2, 13)	7 (0, 11)	0.8819
Vent days	8 (3, 16)	6 (2, 7)	0.2828
Ischemic Paraplegia	0 (0%)	1 (14%)	0.0909
Visceral Ischemia	0 (0%)	2 (28%)	0.0909
Stroke after TEVAR	1 (2.8%)	1 (14%)	0.309
AKI requiring HD	1 (1.4%)	2 (29%)	0.0206
Lower extremity Ischemia	1 (1.4%)	3 (43%)	0.0001



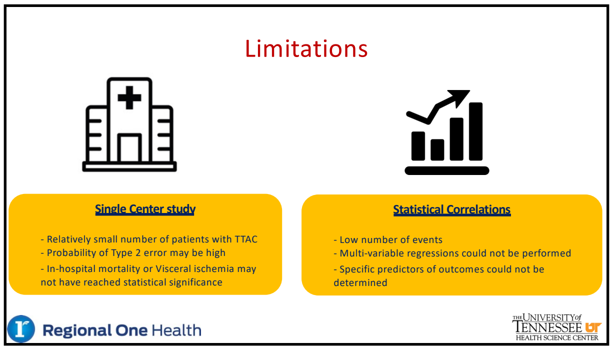
Patient outcomes

Overall in-hospital mortality
7.8%

BTAI-related mortality
2.6%

BTAI + TTAC mortality
29%

	No Pseudocoarctation (n = 70)	Pseudocoarctation (n = 7)	p-value
Time to TEVAR (hrs)	11 (5, 38)	4 (4, 6)	0.0376
In-hospital mortality	4 (5.8%)	2 (29%)	0.0918
Hospital LOS	4 (0,8)	7 (0,9)	0.6466
ICU LOS	4 (2, 13)	7 (0, 11)	0.8819
Vent days	8 (3, 16)	6 (2, 7)	0.2828
Ischemic Paraplegia	0 (0%)	1 (14%)	0.0909
Visceral Ischemia	0 (0%)	2 (28%)	0.0909
Stroke after TEVAR	1 (2.8%)	1 (14%)	0.309
AKI requiring HD	1 (1.4%)	2 (29%)	0.0206
Lower extremity Ischemia	1 (1.4%)	3 (43%)	0.0001



Limitations

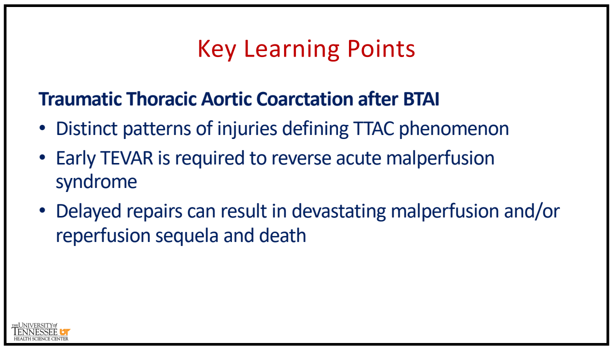
Single Center study

- Relatively small number of patients with TTAC
- Probability of Type 2 error may be high
- In-hospital mortality or Visceral ischemia may not have reached statistical significance

Statistical Correlations

- Low number of events
- Multi-variable regressions could not be performed
- Specific predictors of outcomes could not be determined

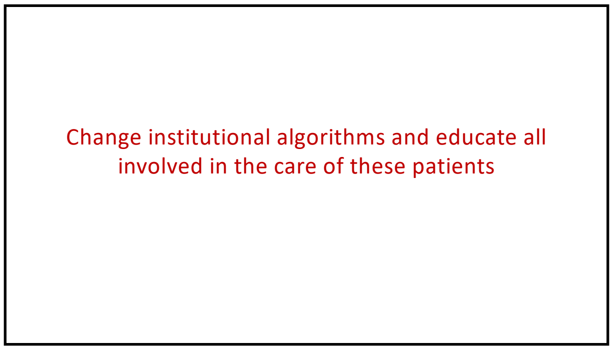
Regional One Health



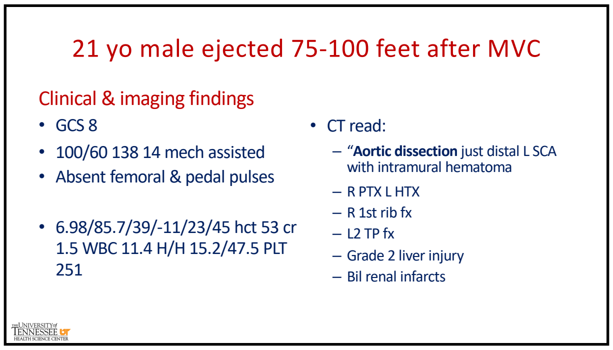
Key Learning Points

Traumatic Thoracic Aortic Coarctation after BTAI

- Distinct patterns of injuries defining TTAC phenomenon
- Early TEVAR is required to reverse acute malperfusion syndrome
- Delayed repairs can result in devastating malperfusion and/or reperfusion sequela and death



Change institutional algorithms and educate all involved in the care of these patients

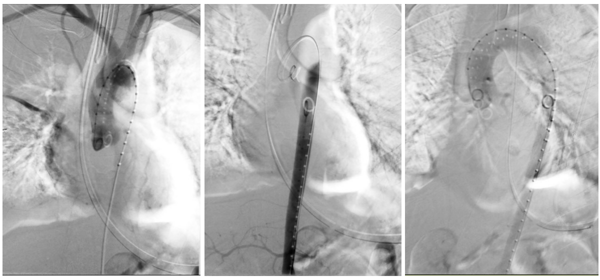


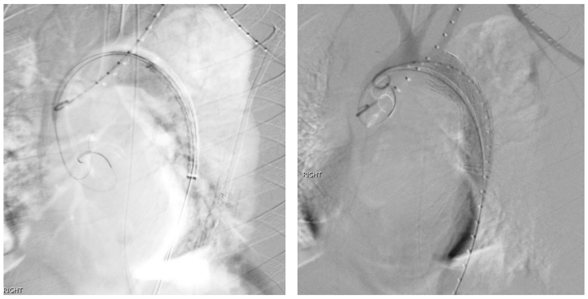
21 yo male ejected 75-100 feet after MVC

Clinical & imaging findings

- GCS 8
- 100/60 138 14 mech assisted
- Absent femoral & pedal pulses
- 6.98/85.7/39/-11/23/45 hct 53 cr 1.5 WBC 11.4 H/H 15.2/47.5 PLT 251

- CT read:
  - "**Aortic dissection** just distal L SCA with intramural hematoma
  - R PTX L HTX
  - R 1st rib fx
  - L2 TP fx
  - Grade 2 liver injury
  - Bil renal infarcts





21 yo male ejected 75-100 feet after MVC

Interventions

- TEVAR 31mm x 10cm <u>@ 6 hrs</u>
- **Delays in care:**
  - Misleading radiology read
  - Extraneous communication chain between teams
  - Lack of standard "alerting" pathway between ED-radiology-trauma surgeons-vascular surgeons-OR/IR/hybrid OR teams

Unexpected post-op course

- Cardiac arrest immediately post deployment of TEVAR
- Death despite aggressive resuscitation, CPR, ROSC temporarily

Key Learning Points

Traumatic Thoracic Aortic Coarctation after BTAI

- Distinct patterns of injuries defining TTAC phenomenon
- Early TEVAR is required to reverse acute malperfusion syndrome
- Delayed repairs can result in devastating malperfusion and/or reperfusion sequela and death
- Standard pathway to expedite care is essential

Questions?