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Frequency of Aortic Miscannulation During Fluoroscopy-Free Endovascular Navigation

Sruti Prathivadhi-Bhay

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Introduction

Cases of non-compressible hemorrhage from the torso and extremities are major contributors of mortality.

Large diameter, compliant aortic balloons (REBOA) have been used for hemorrhage control to manage shock in these cases. However, this technology critically depends on non-portable heavy imaging equipment for navigation. Even with imaging, this navigation is challenging. Moreover, this equipment is not routinely available in remote rural areas or on the battlefield.

Thus, it is crucial to develop a method for “blind” balloon navigation. The goal of this project is to use detailed morphometric characterization of vascular anatomies in subjects of different ages to perform this navigation.

The goal of this project is to validate morphometric calculations by comparing results seen on the Mentice simulator with previously collected data on cadavers and bench-top models.

Morphometric mapping →Physical navigation of two wires in human cadavers → Recorded rates of misplacement

Morphometric mapping → Reconstructed 3D human cadavers→ 3D printed → Recorded rates of misplacement

Morphometric mapping → Reconstructed 3D human cadavers→ Loaded into Mentice → Recorded rates of misplacement

Methods

Step 1

A total of 10 cadavers (average age 81±13 years, range 54-98 years, 7 male, 3 female) lightly embalmed with glutaraldehyde-based solution and warm-perfused with radiopaque fluid containing calcium carbonate to avoid tissue swelling

Step 2

The cadavers were used to test the feasibility of fluoroscopy-free navigation to aortic Zone 1 using a regular stiffness regular angled guidewire. The wire was passed blindly through the left and the right percutaneous femoral access sites for a distance intended to reach the center of aortic Zone 1 based on torso surface measurements. A total of 3 blind wire passage attempts were made on each side, and the wire was removed entirely and inserted *de novo* for each attempt

Step 3

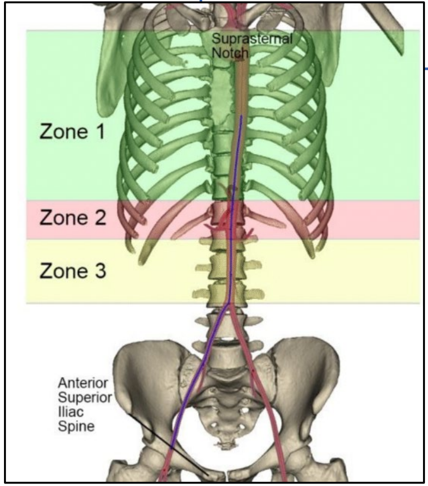
A radiopaque ruler was affixed to each cadaver's chest, and diluted contrast was injected into the aorta to verify the locations of its main branches. The end position of the wire was assessed with fluoroscopy and later verified by co-registering with 3D Computed Tomography Angiography (CTA) Imaging using the affixed ruler as a reference.

Methods

Trauma CT were used to build 3D models

Models exported into Mentice VISTG5 simulator

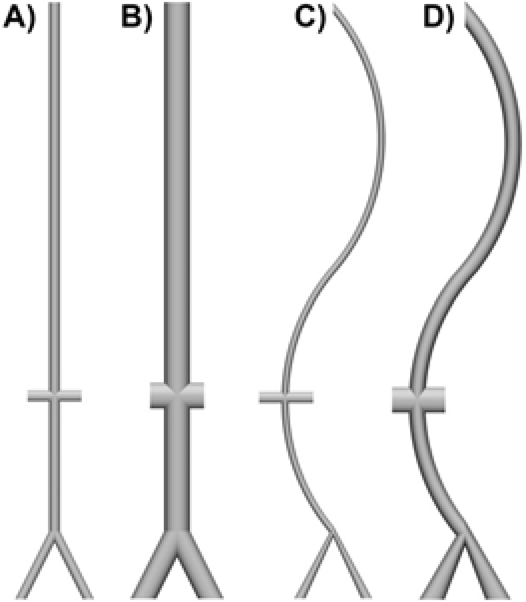
Guidewires (either 0.035” J-curve [JCW] or 0.035” 35-degree angle-tip hydrophilic [ATHW]) were advanced for 12 anatomies

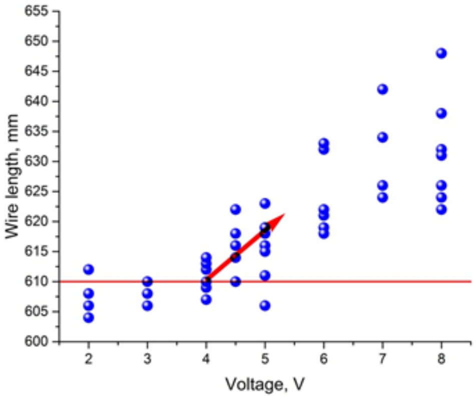


Final locations of guidewire recorded

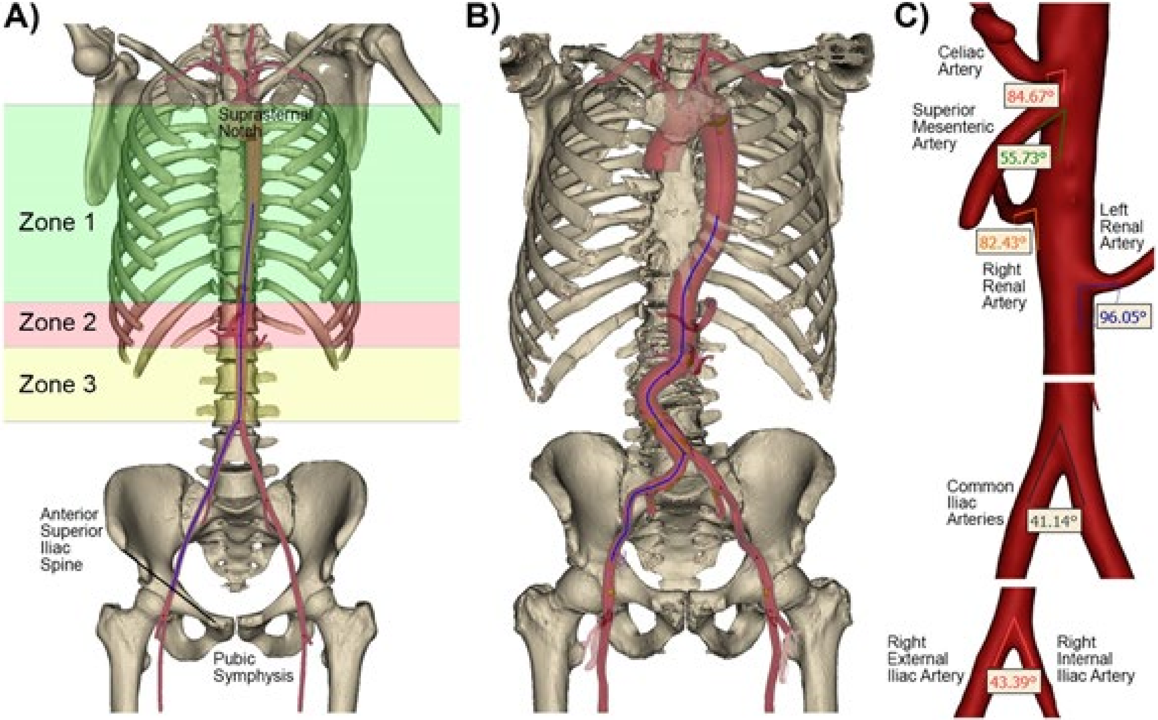
Why Mentice?

- Mentice VIST G5 was chosen because:
  - Can import patient-specific anatomies
  - Provide realistic wire advancements simulations
  - 1-1 geometric scaling
- How does it track the wire?
  - Optic tracking, using sensors
  - We measured the effect of speed and the impact on delivered distance using an automatic wire-feeder and the traveled wire distance
  - Tested at each voltage level several times to assess consistency



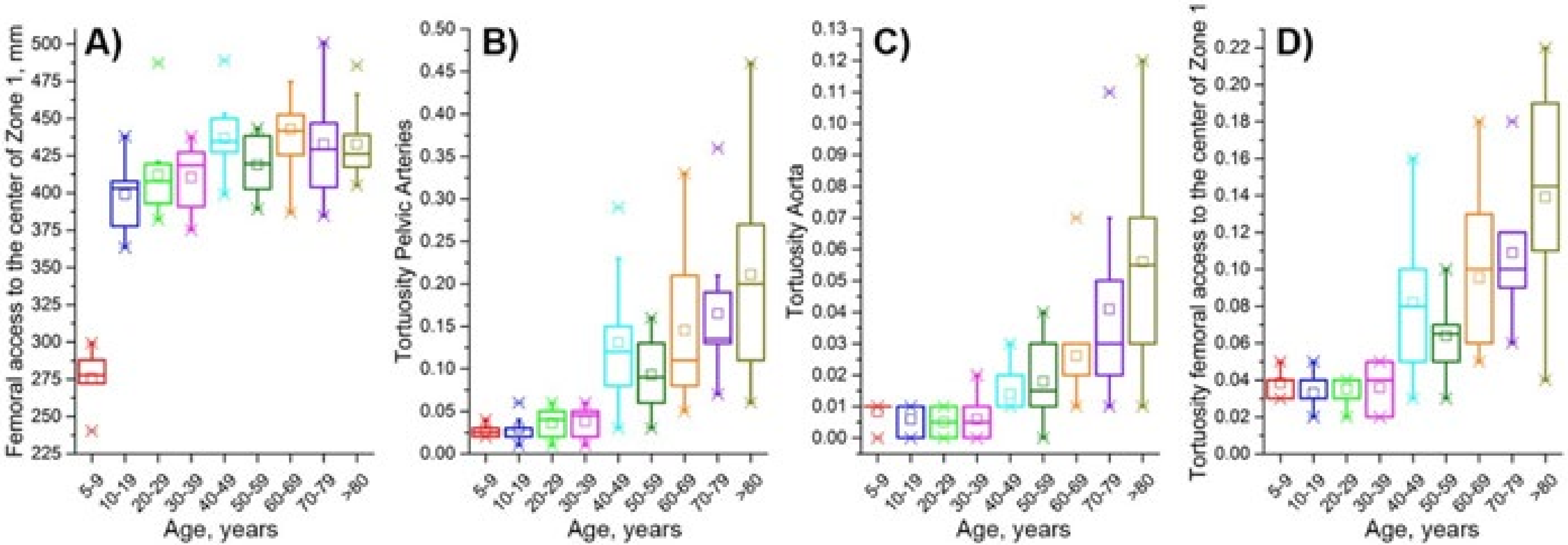


How were zones assessed?

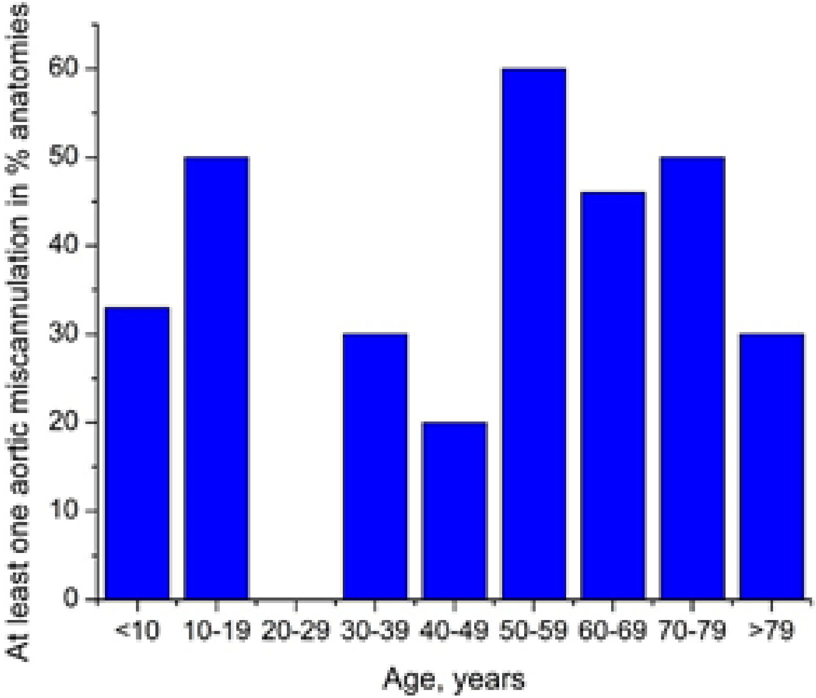


Three-dimensional reconstructions of vasculature and bones in representative young (A) and old (B) subjects. Aortic zones are marked with green, red, and yellow colors. The arterial centerline from the femoral access site to the center of Zone 1 is blue. C) Measurements of branch angles along the catheter's path from the femoral access site to the center of aortic Zone 1.

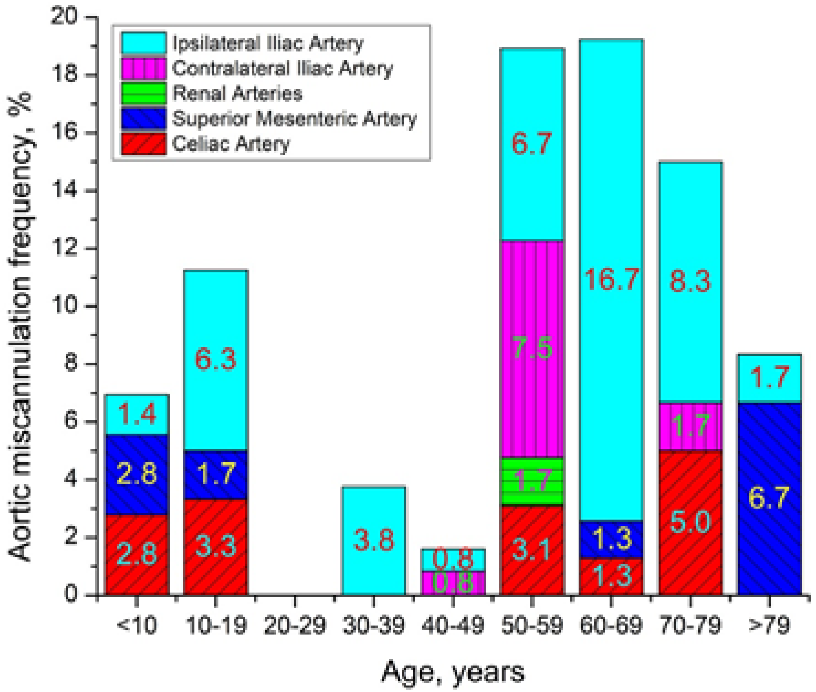
Anatomic Variation as a Function of Age



Frequency of atleast one miscannulation in anatomies of different ages



Aortic Miscannulation Frequency in Different Age Groups



Overall Results

- Aortic miscannulation rate was the same in the cadavers as in the electronic simulator (12%)
- Electronic navigation using a larger cohort (n = 89) demonstrated that misplacements occurred in 36% of all subjects
- Overall miscannulation frequency was 10% in electronic navigation
- Aortic miscannulation rate was lower in <50 year old subjects than in >50 year old subjects
- Most common areas of misplacement were into iliac (5%) > celiac (2%) > superior mesenteric arteries (1%)

Discussion

Fluoroscopy-free Zone 1 aortic cannulation is associated with significant miscannulation rates that are higher in the elderly, likely due to increased vessel tortosity, large diameters and wider angles

As endovascular balloons expands into more austere settings lacking radiographic confirmation of device location, new technology must be developed to help detect and avoid aortic miscannulation and the associated complications