Why Open Repair of AAAs has Improving Outcomes
When is OR Indicated and Better for Patients (??)

I have no relevant financial relationships to disclose at this time

Factors Which Influence Outcomes
- Mortality, morbidity, re-intervention
- Late AAA-related mortality
- Quality of life; value
- Case complexity
  - Age
  - Comorbidities
  - Anatomy
  - Frailty
  - Durability
  - Survival
- Patient preference
- Training
- Surgeon and hospital volume
- Surgeon experience (personal)

General Indications for Open Repair
- Unfavorable anatomy for EVAR*
  - Tortuosity, hostile neck, thrombus
  - Multiple renal arteries
  - Intra-aortic debris or calcification
  - Extensive iliac aneurysms or occlusive disease
  - Horseshoe kidney
  - Dilated IMA
- Complex AAA
- EVAR failure
- Mycotic aneurysm / Infected graft

These operations are often complex
* 20-40% of cases

Abdominal aortic aneurysm: diagnosis and management
NICE guideline
Draft for consultation, May 2018

There is no evidence that EVAR for people with an unruptured infrarenal AAA provides long-term benefit compared to open surgical repair*
- EVAR has fewer perioperative deaths, but more long-term complications requiring more procedures
- There is some evidence that EVAR has worse long-term survival than OR, and EVAR has higher net costs
- Even if long-term benefits were achievable, they are not sufficient to outweigh costs

Contemporary Outcomes for Pararenal AAA*  

<table>
<thead>
<tr>
<th>Variable</th>
<th>Avg %</th>
<th>Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>30d mortality</td>
<td>4.5</td>
<td>1.5 - 37</td>
</tr>
<tr>
<td>Complications/MAE</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Overall cardiac</td>
<td>17</td>
<td>14 - 23</td>
</tr>
<tr>
<td>MI</td>
<td>7</td>
<td>0 - 13</td>
</tr>
<tr>
<td>Pneumonia</td>
<td>8</td>
<td>4 - 11</td>
</tr>
<tr>
<td>Renal</td>
<td></td>
<td></td>
</tr>
<tr>
<td>AKI</td>
<td>1.5</td>
<td>2 - 4</td>
</tr>
<tr>
<td>Temp dialysis</td>
<td>2</td>
<td>0 - 5</td>
</tr>
<tr>
<td>Permanent dialysis</td>
<td>2</td>
<td>0 - 5</td>
</tr>
<tr>
<td>Visceral ischemia</td>
<td>2</td>
<td>0 - 5</td>
</tr>
<tr>
<td>Spinal cord ischemia</td>
<td>1</td>
<td>0 - 4</td>
</tr>
</tbody>
</table>

Factors associated with postoperative renal dysfunction and the subsequent impact on survival after open juxta-renal abdominal aortic aneurysm repair  

- VQI review of all nonruptured juxta-renal AAA  
  - 2835 pts of which 621 (24%) developed AKI  
  - Independent factors assoc with post-op renal dysfx  
    - Renal-visceral ischemia OR 1.6 >25 min; 2.6>40 min  
    - Clamp site OR 1.4 suprarenal; 1.7 supraceliac  
    - Stab/pore OR 1.5  
    - Male sex OR 1.7  
    - Pre-op GFR OR 1.9 GFR 30-45 ml; OR 6.2 GFR>30 ml  

Post-op renal dysfx had 2.6 fold higher risk of early death and 1.5 fold increase in late mortality  

Significant regional variation exists in morbidity and mortality after repair of abdominal aortic aneurysm  

- VQI used after exclusion for <100 AAA repairs  
- No variation in elective OSR (%-7%), but multiple regions had higher mortality than SVS std <5%  
- All regions met benchmark mortality <3% for EVAR  
- Wide variation in LOS, transfusion, post-op MI, AKI and pulmonary complications all of which were significant  

Early reintervention after open and endovascular abdominal aortic aneurysm repair is associated with high mortality  

- ACS NSQIP review of 5877pts with intact infrarenal AAA  
  - OSR 658 (11%) EVAR 5219 (89%)  
  - 261 had early reintervention  
    - Re-Intervention mortality  
      - OSR 28% vs 2.8%  
      - EVAR 12% vs 1%  
      - 10 fold increase in mortality  
      - OSR carried higher risk of re-intervention of any type  

Conversion from endovascular to open abdominal aortic aneurysm repair  

- NSQIP review of 32,164 EVAR patients  
- Outcome with conversion compared to standard open AAA repair and EVAR  
- 300 open conversions  
- Open conversion significantly higher 30-day mortality at 10%, versus 4.2% for open AAA, and 1.7% with EVAR  
- Complications also higher
Defining risk and identifying predictors of mortality for open conversion after endovascular aortic aneurysm repair

2002-2014

- VQI review of EVAR explant compared to open AAA repair
- Explant 159 pts
- Open AAA 3741 pts

Non-adjusted EVAR explant mortality 8% vs 3% OSR

74 yr old man S/P EVAR 2008 with progressive sac enlargement

- No type Ia, possible Ib

Regional Variation

2003: 36 regions did >1 AAA repair / 1000 pts
2013: No area had >0.5 AAA repairs / 1000 pts

80 yo woman with 7 cm pararenal AAA and SMA occlusion

- Aortic tortuosity and angulation
- Down-going, stenotic renal arteries
- Access
- Not a candidate for complex endo repair

Surgical Reconstruction

- Trifurcated graft to renals and SMA
- Straight aortic graft from celiac to bifurcation

Challenges

- Open aortic cases have decreased and are more complex
- Exposure during training far less than even 10 years ago
- Public demand for high value care

The How Questions

- Disseminate best practice models
- Define expertise and technical competence
- Provide succession planning
- Control endovascular exuberance

Regional trends in open surgical, endovascular, and branched-approached endovascular aortic aneurysm repair in Medicare patients

Regional Variation

2003: 36 regions did >1 AAA repair / 1000 pts
2013: No area had >0.5 AAA repairs / 1000 pts
Accurately predicted drop in OAR by fellows to 10 in 2015
Predicts OAR drop to 1-2 for fellows, and 2-3 by IRs by 2020

Issues

Who should do it
- High or low volume surgeons and hospitals
- VS or non-VS surgeons
- Case complexity
- Quality, outcomes and value
- Best practice

How to train
- Fellowship or Integrated residency
  - Hands on
  - Simulation
  - 3-D modelling
  - Cadaver labs
- Focused aortic fellowships
  - Mentorship model
  - Young surgeons
  - 3 mos. to 1 year

Early Outcomes by Surgeon Volume / Experience

- Overall 30 day mortality 3%
- No difference by volume of cases
- Lowest volume group
  - 1.5 fold higher MAE
  - 1.6 fold higher re-op rate
- No differences in post-op outcomes by composite volume or experience
- No differences at 1 year

Not stratified by complexity

Personal Aortic Cases and Mortality 1994-2017*

<table>
<thead>
<tr>
<th>Location</th>
<th>Elective</th>
<th>30d mortality</th>
<th>Rupture</th>
<th>30d mortality</th>
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<tbody>
<tr>
<td>Infraaortic</td>
<td>719</td>
<td>6 ± 0.8</td>
<td>71</td>
<td>12 ± 7</td>
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<tr>
<td>Juxtarenal</td>
<td>543</td>
<td>1 ± 0.1</td>
<td>13</td>
<td>2 ± 15</td>
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<tr>
<td>Pararenal/paravisceral</td>
<td>118</td>
<td>4 ± 3</td>
<td>14</td>
<td>1 ± 7</td>
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<tr>
<td>Thoracoabdominal</td>
<td>165</td>
<td>13 ± 8</td>
<td>23</td>
<td>5 ± 22</td>
</tr>
<tr>
<td>Total</td>
<td>1545*</td>
<td>24 ± 1.6</td>
<td>121</td>
<td></td>
</tr>
</tbody>
</table>

Other etiology**
- Occlusive disease 323 7 ± 2
- Mesoenteric 114 8 ± 7
- Renal 131 3 ± 2
- Infection 71 1 ± 1

Total 639 19 ± 3

* > 500 additional aneurysms 1989-1993
** Primary indication for which aortic reconstruction also done

Continuous Reduction in Operative Mortality*

- Early post op mortality
- Total major aortic cases

2005-2014
- Population-based prospective administrative database
- Annual volume classified by quintiles
- 7211 AAAs by 101 surgeons (81% vascular)
- Multivariable analysis adjusted for age, sex, comorbidities, year of procedure and income
- Endpoints 30d mortality, MAE, reoperation, and 1 year mortality and reoperation
- Very low volume surgeons median 3 cases/yr
- Very high surgeons 54 cases/yr

2014-2017
- Increase in case complexity in last decade

* All patients

Higher surgeon annual volume, but not years of experience, is associated with reduced rates of postoperative complications and reoperations after open abdominal aortic aneurysm repair

<table>
<thead>
<tr>
<th>Year</th>
<th>Early post op mortality</th>
<th>Total major aortic cases</th>
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<tbody>
<tr>
<td>2005</td>
<td>10</td>
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<tr>
<td>2006</td>
<td>8</td>
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<td>2016</td>
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<tr>
<td>2017</td>
<td>0</td>
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</table>
Summary

- Open AAA repair is still valuable
- There is significant variability in practice and outcomes, particularly for complex aneurysms
- Case complexity is increasing as surgeon experience is decreasing
- There is no doubt that surgeon experience, support structure, and team approach to care matter