Risk stratification: The UK cardiothoracic experience

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Background

• Around 35,000 adult cardiac surgery procedures performed each year in UK
• In-hospital mortality rate in 2010-11 was 3.4%
What’s risk stratification used for?

Governance

Decision-making

Additive
2

Logistic
1.31%
Motivation

• Total cost = £1.48m/year in England (<1% of the total NHS spend on adult cardiac surgery)*

• Associated with a 50% reduction in risk adjusted mortality*

*Maintaining Patients’ Trust, SCTS, Henley-on-Thames: Dendrite Clinical Systems Ltd, 2011
Infrastructure

Cardiac surgery

Input data locally

Uploaded periodically to central database

Aim: 3 months
Reality: 1 year

Statistician + clinicians

CQC website

National audit

Aim: <1 year
Reality: 3 years

The Society for Cardiothoracic Surgery in Great Britain & Ireland
Sixth National Adult Cardiac Surgical Database Report 2008
Demonstrating quality

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Dendrite Clinical Systems

Coronary artery bypass graft operations
Operations for 3 years ending March 2009: 222 operations performed
Survival rate as expected by UK standards
Percentage range of patients expected to survive taking into account patients' risk factors

Actual survival rate 99.5%

CQC website

National audit
Monitoring methodology

1. Funnel plot
   - Fixed time period (e.g. 3 years)
   - Identify ‘outlier’ units
   - Doesn’t address whether hospitals are getting worse

2. Variable life adjusted display (VLAD) plot
   - Intuitive dynamic summary
   - Doesn’t identify when a unit is an outlier
Funnel plot

All elective & urgent cardiac surgery in England & Wales

Risk-adjusted mortality proportion

Number of cardiac procedures

- National average
- ±2σ
- ±3σ

warrants closer investigation
VLAD plot

Variable Life-Adjusted Display plot for an individual surgeon

- Observed
- Predicted

Predicted deaths - observed deaths

Operation sequence

The bad run

The intervention

Collecting clinical outcomes
Problems to overcome

1. Systematic model miscalibration
2. Data dissemination
3. Pooled vs. separate models
4. Data quality
5. Gaming
6. Subgroup performance
7. Ancillary methodology
Systematic miscalibration
What’s wrong with this?

All elective & urgent cardiac surgery in England & Wales

Risk-adjusted mortality proportion

Number of cardiac procedures
Systematic miscalibration

- **Observed mortality is decreasing**
  - better surgical tools
  - improvements in post-surgery treatment
- **Predicted mortality is increasing**
  - increase in older patients
  - more complex procedures
- **Model validation essential!**
Dynamical modeling vs. periodic recalibration vs. doing nothing

Model coefficients (log-odds)

- Age (adjusted)
- Female
- Pulmonary disease
- Unstable angina
- LV function: moderate
- LV function: poor

Model: Model 1 - Model 2 - Model 3
Data dissemination: past

Abandoned CQC website

The SCTS ‘Blue Book’

512 pages!
Data dissemination: future
Data dissemination: future
Data quality

Outlier surgeon ≠ rogue surgeon

- Missing data
- Input software errors
- Registry cleaning errors
  - Imputation
  - Validation
Pooled vs. separate models

- CABG + MVR + Tricuspid repair = AVR?
- Cardiac surgery is a ‘catch-all’ term
- We could have risk prediction models for:
  1. all procedures (combinations)
  2. all procedures with multiple procedure variables
  3. each procedure group (e.g. CABG, Valve, CABG + Valve, ...)

- Decision depends on application.
Gaming (+ other unexpected extraneous variation)

Distribution of ranks of risk factor prevalence might be expected to homogenous across hospitals

Further investigation required
Subgroup performance

- Stratification does not ensure good model performance
Ancillary methodology

• Multiple testing
  – correction adjustments (e.g. Bonferroni)

• Overdispersion
  – multiplicative variance inflation
  – random effects models