Surgical Checklist Implementation Project: The impact of the WHO Checklist on risk-adjusted clinical outcomes following national implementation

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## Abstract

### Background

In England and Wales, the WHO Surgical Safety Checklist was mandated in January 2009. Our primary objective was to evaluate impact of Checklist compliance on risk-adjusted clinical outcomes, including the influence of Checklist components (Sign-in, Time-out, Sign-out) on outcomes.

### Methods

Data were collected from surgical admissions between March 2010-June 2011 at five academic and community hospitals. The primary endpoint was any complication, including mortality, occurring prior to hospital discharge. Checklist usage was recorded as Checklist completed in full/partly. Multilevel modeling was performed to investigate the association between complications/mortality and Checklist completion.

### Results

6,714 patients were evaluated across general (40%) orthopedic (44%) and urological (16%) surgery. Overall mortality rate was 0.9%. Significant variability in Checklist usage was found: while at least one of the three parts was completed in 96.7% of cases the entire Checklist was only completed in 62.1% of cases. Checklist completion did not affect mortality reduction, but significantly lowered risk of post-operative complication (16.9% vs. 11.2%). This reduction was largely noticed when all three components of the Checklist had been completed (OR 0.57, 95%CI 0.37-0.87,p<0.01). Full completion of the Checklist on all study patients would have been associated with a 14% (95%CI 7%-21%) complication reduction.

**Conclusions**

Implementation of the WHO Checklist was associated with reduced case-mix adjusted complications following surgery. This was most significant when all three components of the Checklist were completed. Full, as opposed to partial, Checklist completion therefore provides a health policy opportunity to further improve Checklist impact on surgical safety and quality of care.

## Background

The World Health Organization (WHO) Surgical Safety Checklist was the main output of the WHO Global Patient Safety Challenge 'Safe Surgery Saves Lives'. The Checklist was initially tested across eight international pilot sites and demonstrated significant reductions in postoperative mortality and morbidity.[1] Use of the Checklist was mandated in January 2009 for the National Health Service (NHS) in England and Wales by the National Patient Safety Agency (NPSA),[2] and hospitals were given 12 months to implement it. Subsequent studies across a number of healthcare systems have further demonstrated a role for checklists in improving quality and safety of surgical care. [1,3,4]

While surgical checklists have been shown to have an important role in improving safety a number of questions remain, in particular the impact of the checklist in cases of differing complexity and the nature and extent of checklist implementation. Most studies of the surgical checklist have not been properly risk adjusted and some have argued that checklists have their main impact in complex cases and, by implication, may be less critical in more routine operations. Understanding the contributory effect of the Checklist independent of case-mix is, therefore, important and has not been fully addressed by existing studies. Using the SURgical PAtient Safety System (SURPASS) checklist, de Vries et al. implied that patient physical status, measured using the American Society of Anesthesiologists physical status classification (ASA), had little effect on the reduction in complications and mortality seen as a result of the SURPASS checklist use.[5] The accuracy of ASA to accurately predict risk of postoperative complications and mortality is, however, debated because of its subjectivity.[6]

Studies of the checklist have generally assumed that the checklist is either used or not used treating it much as a drug that is either given of not given. In reality observational studies have shown that teams that adopt the checklist are highly variable in the way they use it and often do not complete all the required stages. We do not at the moment know how variable usage is in routine practice (outside formal trials) or to what extent incomplete use of the checklist impacts on patient care.
An early study of the implementation of the WHO Checklist during the international pilot evaluation suggested challenges and variation in its implementation. [7] A recent study that included a control group found no impact of the WHO Checklist on safety culture in the operating room. [8] It is possible that a checklist can be seen as 'rite of passage' and provides a false sense of security to the operating room team, but no improvement in safety.[7] A longitudinal study is therefore required to evaluate the effectiveness of the WHO Checklist as it is implemented in the operative setting – a recommendation made explicitly by the NPSA, following the implementation of the WHO Checklist across England and Wales.

The primary objective of this study was to evaluate the implementation of the WHO Checklist within England and Wales on risk-adjusted clinical outcomes, including the influence of the individual Checklist domains to determine whether an association exists between the degree of Checklist completion and clinical outcomes.

**Methods**

<u>Study design and Participants</u>

Use of the Checklist was mandated nationally before this study commenced – hence it was not possible to conduct a randomized controlled study, or a pre/post-implementation study. A longitudinal research design was therefore chosen, which accepted variability of Checklist use across hospitals and operating room teams.

Between March 2010 and June 2011 data were collected at five NHS hospitals, including two academic teaching centers and three community hospitals, under the supervision of the study team of Imperial College London, UK. To ensure, as much as possible, that the study findings would be representative of the NHS more widely, the selected sites represented a strategic spread of geography and institution size (large teaching vs. smaller community hospitals, as defined by the NPSA). At each of the hospitals a local study lead was identified (senior clinician) and a full-time researcher recruited to collect and manage local data.

Inclusion criteria were any admitted patient who underwent a general surgical, urological or orthopedic operation, either electively or as an emergency, under general or regional anesthesia. These three specialties were chosen as they represent the highest volume surgical specialties in England and Wales[9] and provided a broad case-mix of patients, including age, gender, co-morbidities, and operation complexity, reflective of common practice. Patients under 16 years old, vascular surgical or multiple traumas were excluded due to the different physiological and operative scoring criteria for these populations.

Before/after analysis of implementation of the Checklist, as performed by Haynes et al., demonstrated a 4% overall reduction in the incidence of post-operative complications (11% to 7%).[1] As we used a longitudinal study design, similar sample size power calculations could not be performed. Assuming, however, that we would observe at least a 4% reduction in post-operative complication rate (11% to 7%) with a 3 to 1 rate of Checklist compliance to non-compliance, 2809 patients would be needed to show a statistically significant difference at the 5% level for 90% power (2112 patients in checklist compliant group vs. 697 patients in non-checklist compliant group).

The project was reviewed by the UK's National Research Ethics Service (NRES) and was formally approved as a quality improvement study (September 28th 2009).

Data collection and variables

Each local researcher performed continuous prospective data collection after a period of formal study-orientated training and direct observation by the primary study team to standardize the process. Weekly conference calls between the primary study and local teams and regular visits to the local sites maintained quality control. Pre and intra-operative patient data was collected from the anesthesiologist or their team (including anesthesia resident in charge or anesthesia nurse/assistant) in the operating room. Post-operative outcome data was collected from each patient's electronic discharge summary and was supplemented by data gathered by the hospitals' clinical coding departments. Post-discharge outcome data was not recorded. Compliance with Checklist usage (i.e. whether it was completed or not) was assessed for all procedures including completion of the three components of the Checklist (Sign-in, Time-out, Sign-out). Data were collected on a bespoke datasheet that covered the pre-, intra- and postoperative data variables. Data was subsequently transferred into a modified version of the commercially available software package CRAB (CRAB Clinical Informatics Ltd., UK) for analysis.

Post-operative outcome measures, complications and mortality, were defined according to the American College of Surgeons' National Surgical Quality Improvement Program (ACS NSQIP) guidelines [available from: http://site.acsnsqip.org/]. The primary endpoint was any complication, including mortality, occurring prior to hospital discharge.

Physiological and operative derived variables were also entered into the CRAB software to generate the P-POSSUM (Physiological and Operative Severity Score for the enUmeration of Mortality and Morbidity) score for general surgery and urology cases and the orthopedic POSSUM for the orthopedic cases. The CRAB software, using calculations based on POSSUM algorithms, provided the predicted postoperative complication and mortality risk stratification for case-mix adjustment. A list of measured physiological, operative and outcome patient data is available in the Appendix.

Statistical Analysis

Multilevel logistic regression modeling was performed to investigate the association between the dependent variables ‘complication’ and ‘mortality’ and the independent variable ‘checklist completion’ which was grouped into four categories (1: not completed; 2: one part completed; 3: two parts completed; 4: all three parts completed) using two related models. A two-level logistic regression modeling with the “xtlogit” command in STATA (level 1: patients, level 2: attending surgeon) was used. Due to the small number of hospitals (n=5) a three-level regression model was not attempted but hospital was included, as a covariate, in the model. Model one simply accounted for this hierarchical structure of the data and did not adjust for case-mix. Model two additionally adjusted for case-mix (gender, age, POSSUM risk prediction for complication or mortality as appropriate, elective or emergency procedure and surgical specialty). Odds ratios with 95% CIs are presented for the association between Checklist completion and complications/mortality using the ‘not completed’ checklist band as the reference group.

Statistical analyses were performed using STATA, release 10, 2007. Adjusted population-attributable risk fraction (PAF) and 95% CIs were calculated from regression models using the “aflogit” command. Statistical significance was set at $p<0.05$.

## Results

*Patient demographic information*

6,714 patients were included with elective cases making up 83% of the sample (Table 1). General surgery, Orthopedics and Urology contributed 40%, 44% and 16% of cases, respectively. Over half (56%) of patients were of a favorable case-mix with less than a 20% risk of complication; 12.2% had a predicted complication risk of over 50% (Figure 1).

*Compliance with Checklist*

There was significant variability across cases in Checklist completion and although in 96.7% of cases at least one part of the Checklist was completed, in only 62.1% of cases were all three parts completed (Table 2). When only one part of the Checklist was completed this was usually ‘Sign-in’ (64.4%) or ‘Time-out’ (34.4%). When two parts of the Checklist were completed this was typically a combination of ‘Sign-in’ and ‘Time-out’ (93.1%). ‘Sign-out’ was only completed in 64.3% of cases. There was a strong and statistically significant correlation between completion of the three components.

*Checklist compliance and postoperative mortality and morbidity*

Not completing the Checklist was associated with significantly greater risk of complication after surgery (16.9% vs. 11.2%). Completing all three parts of the Checklist was associated with lower risk of complications (9.7%, std. residual -3.1) compared with partial Checklist completion (Table 2). Overall mortality rate was 0.9% with a trend towards a higher mortality rate (1.4%) when the Checklist was not completed.

*Multilevel logistic regression analysis*

Checklist completion was significantly associated with a reduced likelihood of complications in both models one and two (test for linear trend: OR=0.82 95%CI 0.73-0.92, $p<0.01$ and OR=0.79 95%CI 0.70-0.89, $p<0.01$ for model one and model two, respectively). This reduction was largely noticed when all three components of the Checklist had been completed compared to 'not completed' (OR 0.57, 95%CI 0.37-0.87, $p<0.01$, for case-mix adjusted model two). (Table 3)

Checklist completion was not associated with a reduction in mortality (test for linear trend: OR=1.12, 95%CI 0.68-1.82, $p=0.67$ in the case-mix adjusted model). (Table 3)

The explained variance at the attending surgeon level, for complications, was small (4.54% of the variation in complications was explained at this level) but significant, $p<0.01$. For mortality only 1.25% of the variation was explained at the attending surgeon level and was not statistically significant, $p=0.26$.

*Population Attributable Fraction*

Assuming that there is no residual confounding, if all three parts of the Checklist were completed on 100% of occasions then there would be a corresponding 14% reduction in the observed complication rate (95%CI 7% to 21%). No corresponding PAF for mortality was calculated, as there was no significant association between mortality and Checklist completion.

## Discussion

When all three parts of the Checklist were completed, compared with not completing the Checklist, patients were 0.57 times less likely to experience a complication, although a similar association was not seen for mortality. Routinely completing all three parts of the WHO Checklist, which is mandatory in the operating room in England and Wales, could have an important public health impact and could potentially reduce complication rates by 14%. This provides further evidence for the benefits of the Checklist and overcomes a limitation of the pilot evaluation study that was unable to account for case-mix.[1]

A novelty of this study is that it considers how well the Checklist was completed – by evaluating whether it was completed in full or in part. We obtained a reduction in complications as the Checklist completion increased (from one, to two to three components compared with not completing the Checklist at all) with the association only becoming statistically significant for all three components completed. (Table 3) This trend of risk reduction with increasing Checklist completeness is an important finding. It shows that it is the quality of Checklist completion that influences patient outcome and argues against those that see the checklist as a 'tick-box' exercise. 'Sign-out' appeared to play a critical role in the Checklist's impact on outcome with a 4% reduction in observed complication rate when the Checklist was fully completed compared with only two components completed, which were invariably the 'Sign-in' and 'Time-out' (93.1% of occasions). (Table 2) 'Sign-out' was not completed in over a third of cases. We are not aware of any study exploring reasons for this – however, from this study and anecdotal experience, the timing of the 'Sign-out' tends to conflict with work pressures – including the anesthesiologist's pressure to reverse anesthesia and take the patient to recovery, and the surgeon's/nurses' pressure to prepare for the next case. 'Sign-out' is thus seen as a luxury and not done.

Correlating quality of checklist completion and outcomes has been previously assessed. Using the SURPASS checklist, it was shown that the rate of complications, in patients for whom the extent of checklist completion was above the median, was halved.[5] A single institution retrospective study design has demonstrated the benefit, in reducing in-hospital 30-day mortality, of completing the 22 questions in full as opposed to in-part, although the 'partly completed group' was very heterogeneous with anywhere between 1 and 21 questions completed.[10] What is not possible to ascertain from this analysis is how much Checklist completion was a proxy for pre-existing safety attitudes within the operating room team. A recent study found that introducing the Checklist did not improve safety attitudes[8] – a possible reason for this is that the Checklist introduction started from teams/specialties positively disposed towards the Checklist. Further research should clarify the link between safety culture, Checklist usage and outcomes.

A strength of this study was the incorporation of a 'checklist completion' variable with subsequent calculation of a PAF. Performance management in healthcare commonly uses compliance against a standard (targets) as the measurable outcome, but tends to neglect the quality of compliance and the potential public health implications. PAF is the proportional reduction in morbidity or mortality that would occur if exposure to a risk factor were reduced to an alternative ideal exposure scenario (i.e. fully complete vs. incomplete Checklist completion). In this study, 14% of the complications could have been avoided if all three components of the Checklist had been universally completed. This assumes that the model explained all variation and that 100% of the effect was due to the Checklist alone and not due to other missing confounders. As this cannot be said with certainty, this 14% figure represents a crude indication of the potential public health importance of the Checklist. In reality, the contribution of the Checklist could be expected to be lower. Although within this study alone a relatively small number of complications would be prevented by full Checklist completion, extrapolated to a national or global scale would have significant implications for patient morbidity with consequent resource and financial savings. It has been hypothesized that appropriate use of the SURPASS checklist could have intercepted a third of surgical malpractice medicolegal claims.[11]

The study had limitations. The absence of an association between Checklist completion and reduction in mortality likely resulted from a lack of statistical power secondary to the low mortality rate. Although over 60% of patients underwent operations classified as major or complex major and just under a fifth were performed as an emergency, the predicted mortality risk for the majority of patients was under 5% (93% of patients). The low observed mortality rate, about 1%, was very similar to previous studies that have reported an association between checklist use and mortality although not all adjusted for patient comorbidities.[1,5,10] These previous studies, however, did use a before/after study design, which would have provided the necessary statistical power in the presence of low mortality rates. Our study was intentionally designed as a longitudinal study, to be carried out in parallel with the ongoing national implementation of the WHO Checklist and to be distinct from a controlled trial environment. The uncertainty over Checklist compliance rates, therefore, had to be accepted a priori.

A further limitation of the study was to only include in-hospital outcomes, although we did not limit this to 30-day outcomes as has been done previously. It is plausible, therefore, that the complication rate has been underestimated and in particular readmission data were not captured. Although there was clear association between improved outcomes and the degree of Checklist completion, there was a strong correlation between having completed one part of the Checklist, e.g. Sign-in, and having completed another one. This is termed 'multicollinearity' and therefore to overcome this, 'checklist completion' was derived as a categorical variable with four mutually exclusive categories. It was not possible to investigate multicollinearity further as the 'Sign-out' and 'Time-out' were the only Checklist parts completed in three and 93 cases, respectively. Furthermore, when two of the Checklist components were completed invariably this was the ‘Sign-in’ and ‘Time-out’ in combination.

From a health policy perspective, the full potential that checklists could bring has not yet been realized, beyond knowing that they generally have a positive impact.[13, 14] As with any novel safety improvement tool, there is initially a focus on the crude impact at implementation and mandating often leads to high reported rates of compliance. Over time, the need arises to understand why and how the effect has been brought about to facilitate true behavioral change (i.e. avoid ‘ticking the box’ behaviors) to really benefit patients. In the future it is plausible that checklists that span the entire patient pathway will evolve further.[12] A better understanding of the relationship between checklists, and of the domains within a single checklist, will not only facilitate use on a day-to-day basis in perioperative care but also guide further checklist development and integration and prevent them being seen as a means to achieve compliance against a performance target.

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**Figure Legends**

Figure 1 - Patients categorized according to complication risk decile using POSSUM methodology for case-mix prediction.

Table 1 – Demographics of hospitals and patients included within study

| **Hospital** | **Number of sites within hospital contributing data** | **Number of beds in hospital** | **Number of cases (Proportion of total patient cohort)** | **Proportion Elective surgery†** | **Proportion Emergency surgery†** | **Proportion Minor/Moderate surgery** | **Proportion General Surgery†** | **Proportion Orthopaedic†** | **Proportion Urology†** |
|---|---|---|---|---|---|---|---|---|---|
| **A** | 5 | 420 | 1542 (23%) | 89% | 11% | 36.1% | 32.7% | 55.3% | 11.9% |
| **B** | 3 | 1600 | 2207 (32.9%) | 88.3% | 11.7% | 34.8% | 47.4% | 30.0% | 22.6% |
| **C** | 2 | 620 | 1424 (21.2%) | 73.3% | 26.7% | 13.9% | 38.9% | 48.1% | 13.0% |
| **D** | 2 | 2200 | 753 (11.2%) | 74% | 26% | 9.2% | 28.0% | 65.1% | 6.9% |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **E** | 7 | 1755 | 788<br><br>(11.7%) | 84.1% | 15.9% | 5.9% | 44.7% | 35.0% | 20.3% |
| **Overall** | | | **6714** | **83.2%** | **16.8%** | **35.2%** | **39.7%** | **44.2%** | **16.1%** |

†Within the hospital

Table 2 – Prevalence, across all cases, for checklist completion and associated complication and mortality rates.

| **Total parts of the checklist used** | **Total number of cases (%)** | | **Any complication** | **Mortality** |
|---|---|---|---|---|
| None | 220 (3.3) | | | |
| | | Count | 37 | 3 |
| | | Expected Count | 24.8 | 2.0 |
| | | % within total parts of the checklist used | 16.9% | 1.4% |
| | | Std. Residual | 2.4 | 0.7 |
| ≥ One | 6494 (96.7) | | | |
| | | Count | 724 | 56 |
| | | Expected Count | 736.2 | 57.0 |
| | | % within total parts of the checklist used | 11.2% | 0.9% |
| | | Std. Residual | -0.4 | -0.1 |
| One | 270 (4.0) | | | |
| | | Count | 41 | 1 |
| | | Expected Count | 30.6 | 2.4 |
| | | % within total parts of the checklist used | 15.2% | 0.4% |

| | | | | |
|---|---|---|---|---|
| | | Std. Residual | 1.9 | -0.9 |
| Two | 2052 (30.6) | | | |
| | | Count | 278 | 14 |
| | | Expected Count | 232.6 | 18.3 |
| | | % within total parts of the checklist used | 13.6% | 0.7% |
| | | Std. Residual | 3.0 | -1.0 |
| Three | 4172 (62.1) | | | |
| | | Count | 405 | 41 |
| | | Expected Count | 472.9 | 36.4 |
| | | % within total parts of the checklist used | 9.7% | 1.0% |
| | | Std. Residual | -3.1 | 0.8 |
| **Total** | **6714** | | **11.3%** | **0.9%** |

201 missing data points for mortality & 7 for complication

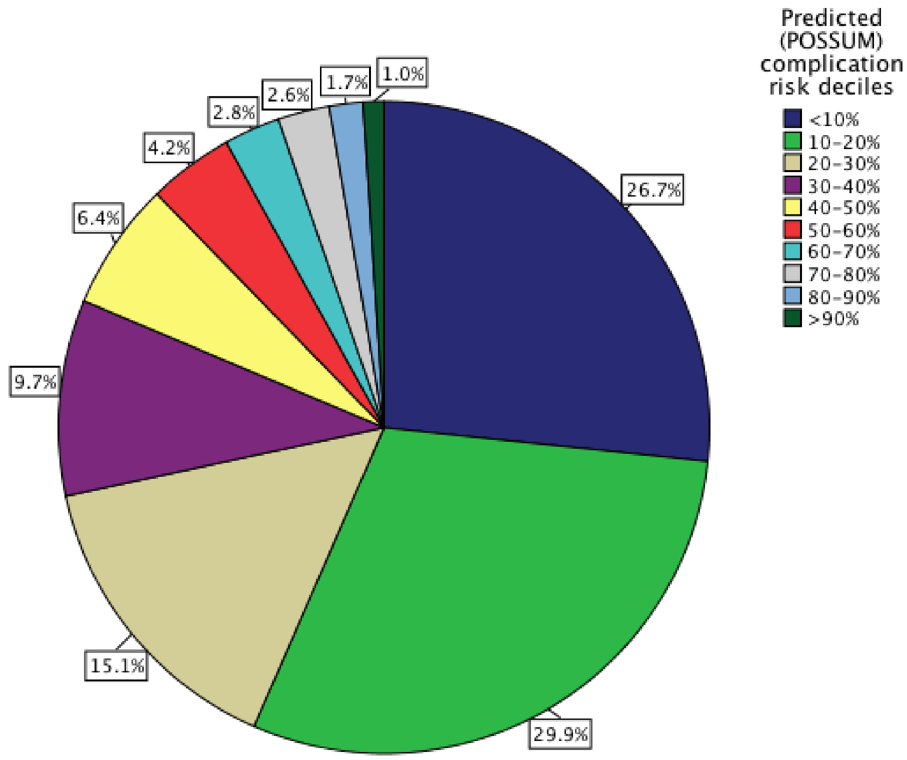
Table 3 – Association between completion of the WHO surgical checklist and complications / mortality risk in five English NHS hospitals: Two-level logistic regression model (n=6714 patients nested within n=228 attending surgeons)

| | | **Complications** | | | **Mortality** | |
|---|---|---|---|---|---|---|
| | | **Model one OR† (CI, p value)** | **Model two (Case-mix adjusted) OR (CI, p value)** | | **Model one OR (CI, p value)** | **Model two (Case-mix adjusted) OR‡ (CI, p value)** |
| **Total parts of the checklist used** | **None** | 1 (reference) | 1 (reference) | | 1 (reference) | 1 (reference) |
| | **One** | 0.88 (0.53-1.45, 0.61) | 0.98 (0.58-1.67, 0.95) | | 0.23 (0.02-2.25, 0.21) | 0.29 (0.02-3.41, 0.33) |
| | **Two** | 0.82 (0.55-1.21, 0.31) | 0.83 (0.55-1.26, 0.38) | | 0.50 (0.14-1.75, 0.28) | 0.59 (0.13-2.71, 0.50) |

| | | | | | | |
|---|---|---|---|---|---|---|
| | **Three** | 0.59 (0.39-0.88, 0.01) | 0.57 (0.37-0.87, <0.01) | | 0.58 (0.17-2.02, 0.39) | 0.76 (0.16-3.53, 0.72) |
| *Test for Linear Trend* | | 0.82 (0.73-0.92, <0.01) | 0.79 (0.70-0.89, <0.01) | | 1.00 (0.67-1.51, 0.99) | 1.12 (0.68-1.82, 0.67) |

†Model one odds ratios accounted for the hierarchical structure of the data (two-level logistic regression (level 1: patients, level 2: attending surgeons) with hospital included as a covariate. ‡Model two odds ratios additionally adjusted for case-mix (gender, age, POSSUM risk prediction for complication or mortality as appropriate, elective or emergency procedure and surgical specialty)

Figure 1


Predicted (POSSUM) complication risk deciles
<10%
10-20%
20-30%
30-40%
40-50%
50-60%
60-70%
70-80%
80-90%
>90%
26.7%
29.9%
15.1%
9.7%
6.4%
4.2%
2.8%
2.6%
1.7%
1.0%

**Appendix**

Physiological and operative derived variables to generate the P-POSSUM (Physiological and Operative Severity Score for the enUmeration of Mortality and Morbidity) score for general surgery and urology cases and the orthopedic POSSUM for the orthopedic cases.

*Physiological*

- Age
    - Age < 60 years
    - Age 61-70
    - Age > 71
- Cardiac signs; CXR
    - No signs of cardiac failure and the patient is not taking cardiac drugs
    - Patient is on diuretics, digoxin, anti-anginal or anti-hypertensive medication, but not anti-coagulants
    - Patient is taking anti-coagulants (excluding prophylactic heparin therapy) or the patient has peripheral oedema or the chest Xray shows borderline cardiomegaly
    - Presence of an elevated jugular venous pressure or cardiomegaly on a chest Xray or pulmonary oedema
- Respiratory signs; CXR
    - No respiratory symptoms and the chest Xray is normal or has not been performed

  - Patient is short of breath on exertion (but is able to tolerate one flight of stairs) or chest Xray shows signs of mild COAD (chronic obstructive airways disease)
  - Patient's exercise tolerance is limited to one flight of stairs or chest Xray shows moderate COAD
  - Patient is short of breath at rest or has a respiratory rate in excess of thirty breaths per minute or is in need of mechanical ventilation or chest Xray shows fibrosis or consolidation
- Systolic blood pressure
  - 110 -130 mm Hg
  - 131 - 170 or 100 - 109
  - > 171 or 90 - 99
  - < 89
- Pulse
  - 50 - 80 beats per minute
  - 81 - 100 or 40 – 49
  - 101 – 120
  - > 121 or < 39
- Glasgow coma score
  - 15
  - 12 – 14
  - 9 – 11
  - < 8
- Urea
  - < 7.5 mmol / litre

    - 1.6 – 10
    - 10.1 – 15
    - > 15.1
- Sodium
    - > 136 mmol / litre
    - 131 – 135
    - 126 – 130
    - < 125
- Potassium
    - 3.5 - 5.0 mmol / litre
    - 3.2 to 3.4 or 5.1 - 5.3
    - 2.9 - 31. or 5.4 - 5.9
    - < 2.8 or > 6.0
- Hemoglobin
    - 13 - 16 g/100 ml
    - 11.5 - 12.9 or 16.1 - 17.0
    - 10.0 - 11.4 or 17.1 - 18.0
    - < 9.9 or > 18.1
- White cell count
    - $< 3 \times 10^{12}$ cells
    - 4.0 - 10.0 or 3.1 - 4.0
    - 10.1 - 20.0 or < 3.0
    - > 20.1
- Electrocardiogram (ECG)
    - ECG is normal or has not been performed

  - ECG shows controlled atrial fibrillation (rate 60 -90 beats per minute)
  - Rate of fibrillation is greater than 90 or there is any other arrhythmia or there are changes in the T wave or the ST segment
  - If the patient has suffered a Myocardial Infarct, this will probably show on an ECG and lead to a score of 8

*Operative*

- Type of operation
  - Minor procedures, including such procedures as all day case surgery, hernia repair, scrotal surgery, varicose vein surgery, excision of breast lump, node biopsy, minor amputation and cystoscopy. Also included in this group are eyelid and minor E N T surgery.
  - Intermediate surgery, including cholecystectomy (conventional or laparoscopic), mastectomy, thyroidectomy, appendectomy via a RIF incision, transurethral resection of bladder tumour or prostrate, intraocular surgery and reconstructive E N T surgery.
  - Major surgery, covering such procedures as any laparotomy, any bowel resection (conventional or laparoscopic) except those listed below, exploration of the common bile duct (either conventional or laparoscopic), peripheral arterial reconstruction or embolectomy, major amputation and block dissection of the neck.
  - Major+ surgery, covering such procedures as aortic reconstruction, total cystectomy or radical prostatectomy, pancreatic resection, biliary reconstruction, liver resection, oesophagectomy, total gastrectomy, abdomino-perineal resection of rectum and major head and neck surgery.

- Number of operations performed in the preceding thirty days
    - Only one operation has been performed.
    - A second operation performed within 30 days (e.g. mastectomy following an excision biopsy on a previous occasion, or a re-look laparotomy).
    - More than 2 operations are performed within 30 days.
- Blood Loss
    - Less than 100 ml
    - Between 101 and 500 ml
    - Between 501 and 999 ml
    - 1 litre or more
- Peritoneal soiling (for general surgery procedures)
    - Not applicable on many occasions
    - Minor serous soiling or < 250 ml of blood
    - Presence of local pus
    - Free bowel contents, generalized pus or > 250 ml of blood
- For Orthopedic procedures
    - No contamination
    - Incised wound e.g. stab
    - Minor contamination necrotized tissue
    - Gross contamination necrotized tissue
- Malignancy
    - Absence of malignancy
    - No evidence of metastatic spread
    - Evidence of nodal metastases

    - Evidence of distant metastases
- Timing of operation
    - Elective surgery. This includes patients admitted as an emergency who subsequently undergo surgery more than 24 hours after admission.
    - Surgery performed following resuscitation but within 24 hours after admission OR an immediate procedure performed on a patient who does not require resuscitation.
    - Immediate surgery is required, or surgery occurred synchronously with resuscitation

Post-operative outcome measures (as defined according to the American College of Surgeons' National Surgical Quality Improvement Program (ACS NSQIP) guidelines [available from: http://site.acsnsqip.org/]

- Wound disruption
- Pneumonia
- Unplanned intubation for respiratory/cardiac failure
- Deep vein thrombosis
- Pulmonary embolism
- On ventilator over 48 hours in case of elective operations
- Acute renal failure
- Stroke/Cerebrovascular accident
- Coma > 24 Hours
- Peripheral nerve injury

- Cardiac arrest with cardiopulmonary resuscitation
- Myocardial infarction
- Bleeding Requiring > four units PRBC/Whole blood transfusions within first 72 hours after surgery
- Graft/Prosthesis/Flap failure
- Anastomotic failure
- Surgical site infections (superficial incisional /deep incisional /organ Space)
- Systemic sepsis
- Return to the operating room within 30 Days
- Death on day of operation
- Post-operative in-hospital mortality