I. Introduction

The Society of Thoracic Surgeons’ risk models predict the risk of operative mortality and morbidity after adult cardiac surgery on the basis of patient demographic and clinical variables. The models are primarily used to adjust for case mix when comparing outcomes across institutions with different patient populations. Such comparisons are provided in the Database reports received by STS Database participants. The STS models are also used by physicians and patients as tools for understanding the possible risks of surgery. As these risks are solely statistical estimates, they should be supplemented by the professional judgment of the patients’ healthcare provider, particularly their cardiac surgeon.

This overview is provided as background to help users of the online STS risk calculator understand and interpret the results. Throughout this document, variable short names are used frequently. Detailed information on the STS variables, including variable short names and clinical definitions can be found at the STS website - [http://www.sts.org](http://www.sts.org) under the STS National Database tab, Database Managers Section. Brief definitions are also available by clicking the “definitions” link on the risk calculator web page.

II. Surgical Procedures

The STS currently has three risk models: CABG, Valve, and Valve + CABG. The models apply to seven specific surgical procedure classifications:

**CABG model**
1. Isolated Coronary Artery Bypass (CABG Only)

**Valve model**
2. Isolated Aortic Valve Replacement (AV Replace)
3. Isolated Mitral Valve Replacement (MV Replace)
4. Isolated Mitral Valve Repair (MV Repair)

**Valve+CABG model**
5. Aortic Valve Replacement + CABG (AV Replace + CABG)
6. Mitral Valve Replacement + CABG (MV Replace + CABG)
7. Mitral Valve Repair + CABG (MV Repair + CABG)

See Table 3 below for detailed definitions of these procedure classifications.

NOTE: A predicted risk value will NOT be calculated for any procedure that does not fall into one of these precisely defined categories.
III. About the Current Models

The current models were developed during the fall of 2007 using STS Adult Cardiac Surgery Database records for surgical procedures taking place between January 1, 2002 – December 31, 2006. Risk models were developed for the nine endpoints defined in Table 1:

<table>
<thead>
<tr>
<th>Endpoint</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Operative Mortality</td>
<td>STS v2.81 Sequence number 5025 (MiOpD): Operative mortality includes both (1) all deaths occurring during the hospitalization in which the operation was performed, even if after 30 days; and (2) those deaths occurring after discharge from the hospital, but within 30 days of the procedure.</td>
</tr>
<tr>
<td>Permanent Stroke</td>
<td>STS v2.81 Sequence number 4810 (CNStrokP): Postoperative stroke (i.e., any confirmed neurological deficit of abrupt onset caused by a disturbance in blood supply to the brain that did not resolve within 24 hours.</td>
</tr>
<tr>
<td>Renal Failure</td>
<td>STS v2.81 Sequence number 4870 (CRenFail): Acute or worsening renal failure resulting in one or more of the following: 1. Increase of serum creatinine to ≥ 4.0 with an increase of at least 0.5mg/dl or 3x most recent preoperative creatinine level. 2. A new requirement for dialysis postoperatively.</td>
</tr>
<tr>
<td>Prolonged Ventilation &gt; 24 hours</td>
<td>STS v2.81 Sequence number 4835 (CPVntLng): Prolonged post-operative pulmonary ventilation &gt; 24.0 hours. The hours of postoperative ventilation time include OR exit until extubation, plus any additional hours following reintubation.</td>
</tr>
<tr>
<td>Deep Sternal Wound Infection</td>
<td>STS v2.81 Sequence number 4700 (DeepSternInf): Deep sternal wound infection or mediastinitis (according to CDC definition) diagnosed within 30 days of the operation or any time during the hospitalization for the surgery.</td>
</tr>
<tr>
<td>Reoperation for any reason</td>
<td>STS v2.81 Sequence numbers 4755 (CopReBld), 4765 (CopReVlv), 4770 (CopReGf), 4775 (CopReOth), 4780 (CopReNon): Reoperation for bleeding/tamponade, valvular dysfunction, graft occlusion, other cardiac reason, or non-cardiac reason</td>
</tr>
<tr>
<td>Major Morbidity or Operative Mortality</td>
<td>A composite endpoint defined as any of the outcomes listed in the first six rows of this table.</td>
</tr>
<tr>
<td>Short Stay: PLOS &lt; 6 days *</td>
<td>Discharged alive and within 5 days of surgery</td>
</tr>
<tr>
<td>-----------------------------</td>
<td>---------------------------------------------</td>
</tr>
<tr>
<td>Long Stay: PLOS &gt;14 days</td>
<td>Failure to be discharged within 14 days of surgery</td>
</tr>
</tbody>
</table>

*NOTE: The definition of the short patient length-of-stay endpoint differs from previous versions of the STS risk model. In the new definition, patients must be discharged alive in order to receive credit for a PLOS < 6 days.

See Table 4 below for listings of the STS variables contained in each of the STS models.

IV. Patient Population

The models can be applied to all adult patients who fall into one of the surgical procedure populations described in Table 3 below, except as follows:

- The model will only calculate a predicted risk value for adult patients age 18 to 110 years.
- The models will only calculate a predicted risk value for those patients for which both age and gender are known.
- The models for renal failure will NOT calculate a predicted risk value for any patients who are on dialysis preoperatively.

V. Missing Data Handling

**Missing Data**

It is important to understand how missing data values are handled when the STS risk-adjustment models are applied to patients with incomplete data. With the exception of age and gender, missing data values are imputed by assigning a likely substitute value. The algorithm used for missing data imputation is described below.

- **Required variables**: Age and gender are required variables for all models. If either is missing, no value for predicted risk will be calculated.

- **Categorical variables**: Missing data are generally assumed to have the lowest risk category. For example, if diabetes was not coded, it would be assumed to be “No”; if procedure priority were not coded, the procedure would be assumed to be “Elective.” In most cases, the lowest risk category is also the most frequent.

- **Continuous variables**: Table 2 shows the values assigned to missing data for continuous model variables.
### Table 2. Imputation of Missing Continuous Variables

<table>
<thead>
<tr>
<th>Model Variable</th>
<th>Model Imputation Information</th>
</tr>
</thead>
</table>
| Body Surface Area (BSA)         | If gender is “Male” set BSA = 2.00m²  
If gender is “Female” set BSA = 1.75m²                                                     |
| Ejection Fraction (EF)          | CABG Model  
If CHF is no or missing, set EF = 50%  
If CHF is yes and gender is Male, set EF = 35%  
If CHF is yes and gender is Female, set EF = 45%  
Valve Model  
Set EF = 50%  
Valve+CABG Model  
If CHF is yes and gender is Male, set EF = 40%  
Otherwise, set EF = 50%                                                                  |
| Last Preop Creatinine           | Set creatl = 1.0                                                                              |

### VI. Predicted Risk Values

After information has been entered on a given case, the online STS risk calculator provides a risk percentage for each of the outcomes. The risk percentage is the estimated percentage estimates the chance of a specific outcome for a patient with the indicated risk factors. Please note that the calculator updates the risk percentage for each outcome as each question is answered; therefore, the most reliable risk percentage will appear only after all available data have been entered.

**A note on interpretation of values**

The inherent limitations of statistical risk-adjustment models should be kept in mind when interpreting risk percentage values for an individual patient. Risk adjustment attempts to take into account as many of the patient’s risk factors as possible. However, there are potentially difficult-to-measure factors that are not included in the STS risk-adjustment models and which may increase or decrease a patient’s risk of an adverse outcome.

As with any statistical estimates, the risk percentage values should be supplemented by the professional judgment of the patients’ healthcare provider, particularly their cardiac surgeon.

**Links to Procedure ID and Risk Model Variables**

- [Procedure Identification Table v2.81](#)
- [Risk Model variables 2.81](#)