

# Evaluating a Trainee's Progress in Surgical Dexterity

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## Abstract

The local cardiac surgical training program is modelled on a one-to-one apprenticeship encompassing a number of years. Trainee progress is regularly audited and work of increasing complexity is provided, commensurate with the trainee's ability.

Speed and accuracy are desirable surgical goals and reflect a high level of decision-making and dexterity. The trainee's surgical speed over a period of time was monitored as one measure of progress. The mean time required to complete a coronary anastomosis (graft time) decreased from 12.8±1.9minutes in the first year of training to 9.0±1.9minutes in year four, inter-group variance (ANOVA) was highly significant from year two to year three and from year three to year four ( $p < 0.001$ ).

Risk stratification was utilised in the selection of patients for the trainee. Parsonnet score increased from 5.1±3.5 in year one to 6.0±5.0 in year four. Similarly, EuroSCORE increased from 2.1±1.8 to 2.4±2.1. Additionally, variable life-adjusted display (VLAD) plots were constructed in order to provide a visual representation of performance against predicted outcome by EuroSCORE. Successive VLAD plots demonstrate the changing practice of the trainee as it came to resemble more closely that of his instructor and this was achieved without jeopardising patient outcome.

## Introduction

A good surgeon shows sound clinical judgement, superior surgical skill and compassion to patients. Surgery has traditionally relied on speed. With the advent of anaesthesia the surgeon was given more opportunity to refine his skills of dexterity. This allowed for the development of less painful and more effective operations. However, speed and accuracy still form the cornerstones of surgical skill.

## Methods

The trainee is first taught to perform portions of the operation with the instructor acting as first assistant, beginning with sternotomy and closure and eventually progressing to

saphenous vein, radial artery and internal thoracic artery harvesting. These procedures are later alternately performed independently by the two surgeons. Each step is supervised for accuracy and effectiveness and any related complications that may arise are recorded. Thus with sternotomy and closure sternal stability, postoperative bleeding, wound infection and the cosmetic result are recorded. Figure 1 shows our incidence of resternotomy for postoperative bleeding over a 9 year period, during which time 2800 cases were performed. This complication occurred with a mean rate of 0.9% (3.4% in the UK during 2003).<sup>1</sup>

The next step to master is cannulation of the aorta and right atrium in order to place the patient on cardiopulmonary bypass. The process of cardiopulmonary bypass, whereby the patient's blood is diverted through an extracorporeal circuit, oxygenated, temperature-regulated and pumped into the aorta, is unphysiological, and for this reason we endeavour to keep its duration to a minimum.<sup>2</sup> Typically bypass runs in our unit are under one hour. Speed is now of essence, particularly during the period of myocardial ischaemia,<sup>3,4</sup> which takes up approximately half the bypass time. The first part of bypass is utilised to inspect the heart and plan the operation (Figure 2). During this time the coronary arteries are inspected and, in the light of the preoperative angiographic findings, decisions are made as to which arteries are to be grafted and the precise site of anastomosis. The various conduits are suitably chosen and, when all is prepared, the aortic cross-clamp is applied and the cardioplegia administered. This initiates the period of myocardial ischaemia and the period we have chosen to assess surgical dexterity. The period of ischaemia ends with controlled reperfusion of the heart via the grafted left internal thoracic artery.<sup>5</sup> The aortic cross-clamp is removed soon after. During the period of reperfusion on bypass the proximal anastomoses between the vein grafts and the aorta are fashioned. The patient is then weaned from cardiopulmonary bypass and the chest closed.

## Graft time

The graft time was defined as the ischaemic time divided by the number of distal anastomoses performed. During the ischaemic period final decisions were also taken regarding which vessels to graft, the site, size and configuration of the anastomosis, the conduct of cardiopulmonary bypass and the administration of cardioplegia according to protocol for myocardial protection.

## Risk stratification

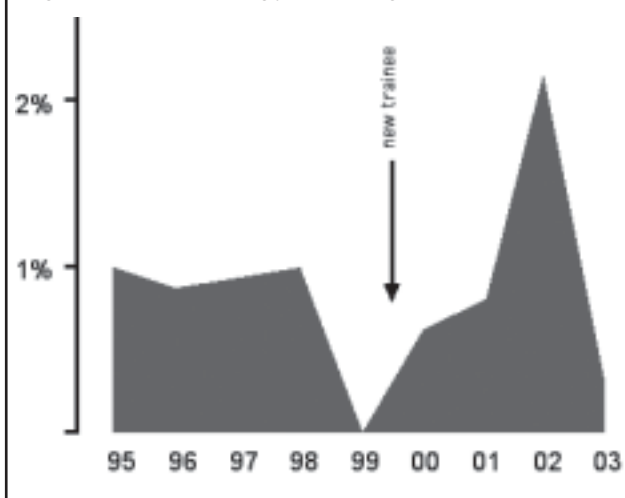
Patients are risk-stratified as part of the decision process in their selection for surgery. Two systems are employed namely the Parsonnet,<sup>6</sup> which has been in widespread use for 15 years, and the EuroSCORE,<sup>7</sup> a more recent method that better reflects contemporary outcome.

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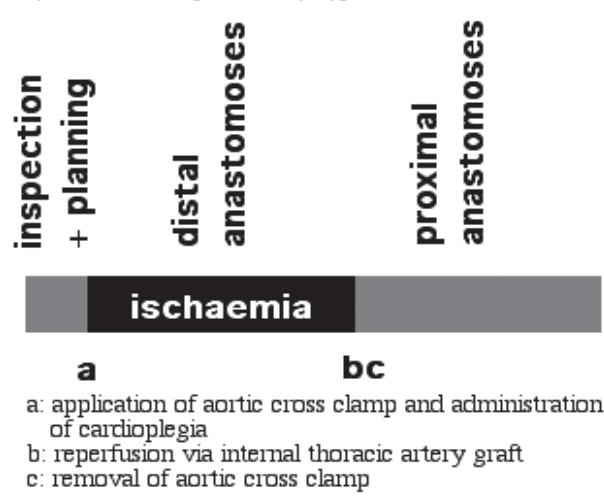
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**Figure 1: Resternotomy for bleeding**



**Figure 2: Cardiopulmonary bypass**



**Variable life-adjusted display**

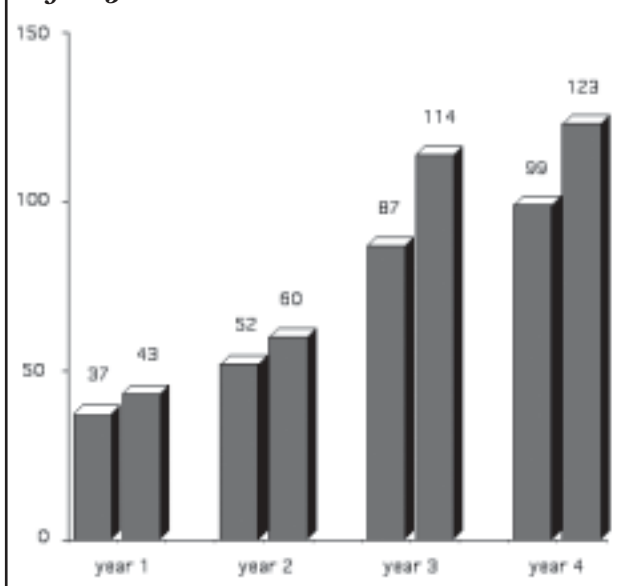
The VLAD, or variable life-adjusted display, attempts to provide a visual representation of performance against predicted outcome.<sup>8</sup> Operative sequence is plotted on the x axis for a particular surgeon. If a patient whose predicted mortality by EuroSCORE is 5% survives surgery the graph increases by 0.05; if a patient whose predicted mortality is 20% dies the graph decreases by 0.8 (1-0.2). The death of a high risk patient is therefore appropriately weighted. If the number of patient deaths is fewer than expected the VLAD values are positive. If outcome is worse than predicted the VLAD values are negative. The baseline represents the predicted outcome by EuroSCORE.

**Results**

**Case load**

Figure 3 shows the number of bypass cases performed by a single trainee over a four year period 2000 to 2004, starting from 37 in the first year and progressing to 99 in the fourth year. Also shown is his case-mix with 82% of his 4th year work being bypass grafts and the remainder mainly valve surgery, reflecting the work-mix of the unit.

**Figure 3: Trainee workload: CABG and total cases**



**Graft time**

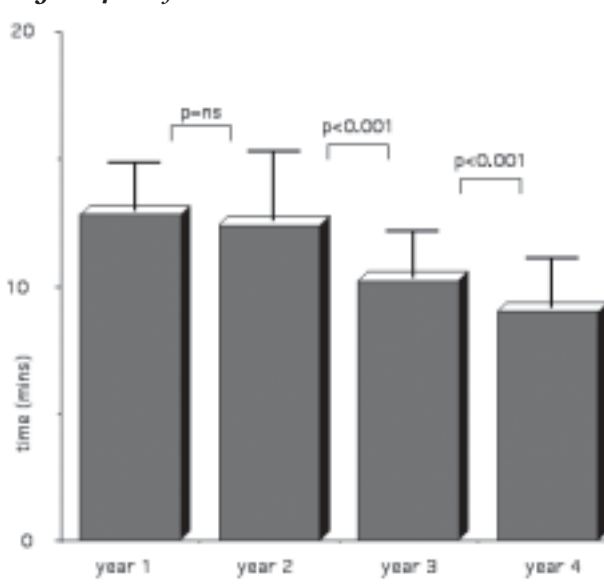
Mean graft time (Figure 4) decreased from 12.8±1.9min in year one, to 12.4±2.7 in year two (p=ns), to 10.2±1.8 in year three (p<0.001) and to 9.0±1.9 in year four (p<0.001) (inter-group variance by ANOVA).

Our results demonstrate a progressively shorter graft time over four years. During this training period the volume and complexity of the trainee's work increased.

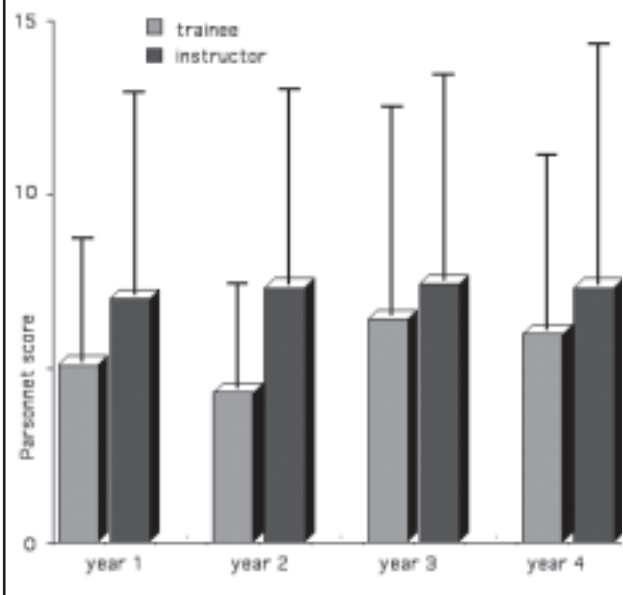
**Risk stratification**

Figure 5 shows the mean Parsonnet scores of patients operated on by the trainee over the 4 year period as compared with those of the instructor. The trainee's patients increased in risk over the 4 year period but were always of lower risk than those of the instructor.<sup>9</sup> Similarly the EuroSCORE figures for the trainee show a progression in risk over the years but were consistently lower than those of the instructor (Figure 6).

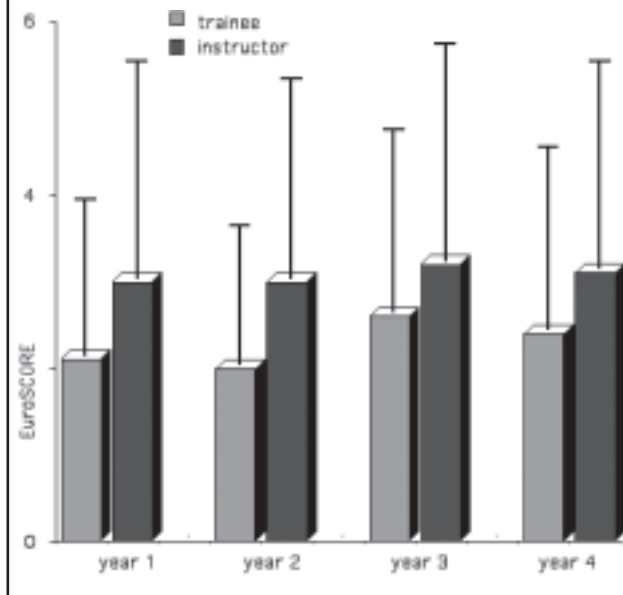
**Figure 4: Graft time**



**Figure 5: Parsonnet scores of patients**



**Figure 6: EuroSCORE figures for trainee**



**Variable life-adjusted display**

Figure 7 shows the VLAD plot for year one using the EuroSCORE as predictor. The trainee performed 43 operations with no deaths. The instructor performed 246 operations with 2 deaths. The predicted deaths by EuroSCORE were 8.1, the actual deaths were 2. The 6.1 fewer deaths than predicted are shown graphically on the VLAD plot, 1 from the trainee and 5.1 from the instructor. The situation in his 4th year of training is, however, vastly different (Figure 8). He has now performed 123 cases, he has had one death, and the slope of his plot is closer to that of his instructor. The instructor has performed 156 cases with 2 deaths. The predicted deaths by EuroSCORE were 7.7, the actual deaths were 3. The 4.7 fewer deaths than predicted are shown graphically on the VLAD plot, 2 from the trainee and 2.7 from the instructor.

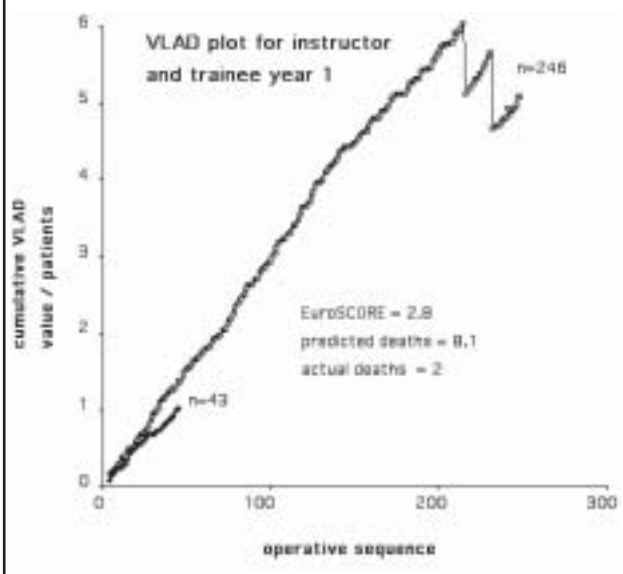
**Postoperative ventilation**

Figure 9 shows the mean postoperative periods of mechanical ventilation. The increased ventilation periods required for the instructor's cases, reflecting higher risk patients, disappeared by year four. A trend towards shorter ventilation periods was a result of our unit's policy.

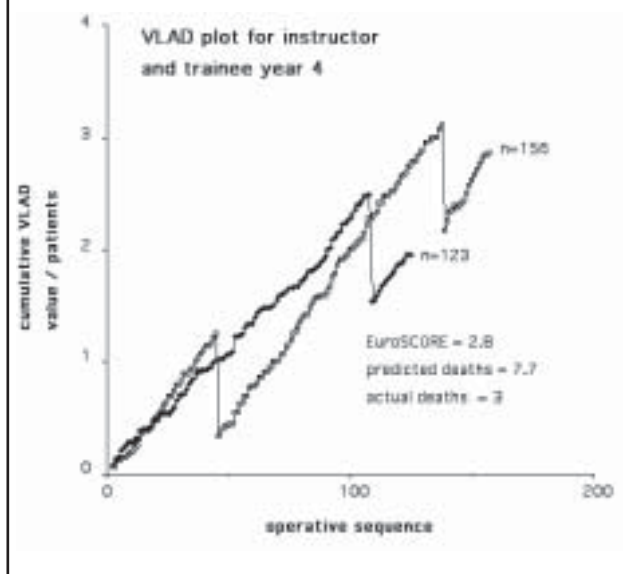
**Postoperative blood loss**

Figure 10 shows the mean postoperative blood loss which increased over the four year period, reflecting the larger proportion of patients undergoing surgery while still on anti-platelet treatment. Results were similar for the trainee and the instructor.

**Figure 7: Variable life-adjusted display: year 1**



**Figure 8: Variable life-adjusted display: year 4**



### Postoperative complications

Table 1 lists the complications by system over the four year study period for the trainee and instructor. Systems included are cardiac, respiratory, gastrointestinal, renal and neurological, followed by infective complications and re-sternotomy for bleeding. There were more cardiac and renal complications and fewer neurological complications in the instructor's practice.

### Discussion

Short ischaemic periods are associated with fewer early postoperative complications and precise anastomoses result in grafts with optimal flow. The time required to complete a task reflects the ease with which the surgeon can undertake that task. The shorter graft times achieved over this 4 year study period reflect the increasing competence of the trainee, both in his powers of judgement, and dexterity. Auditing trainee progress is a complex process but measuring surgical speed in a

controlled clinical situation may provide a meaningful guide.

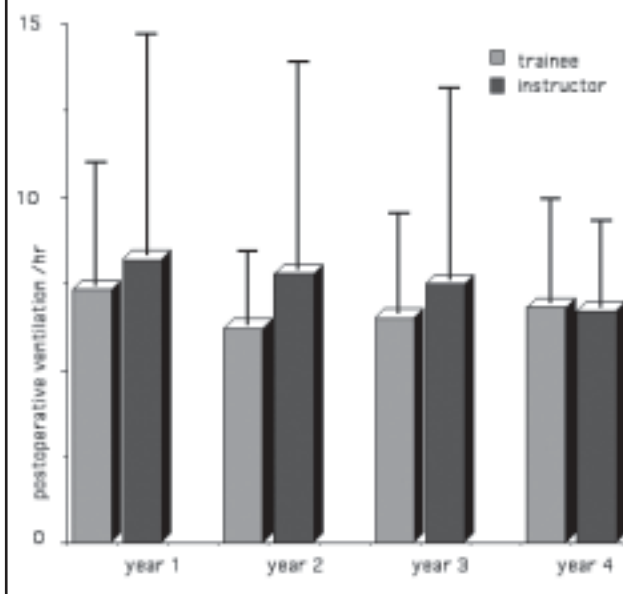
The points to notice about this trainee's early performance is that his numbers were small, he had no deaths in the first year and the slope of his plot is less steep than that of his instructor, denoting lower risk patients. The VLAD plots over progressive years of training show that the trainee surgeon has performed more operations, that the complexity of the surgery has increased, that mortality is inevitably creeping into his practice, but that his results are still better than predicted by the EuroSCORE stratification. These observations were borne out in similar studies.<sup>10-12</sup>

A trend towards higher cardiac and renal complications in the instructor's practice may reflect the higher risk of his patients. Interestingly this trend was not observed with regard to neurological complications. This area is a complex one and postoperative neurological events are thought to reflect both patient factors as well as operative technical ones such as handling

**Table 1: Complications**

	Trainee					Instructor				
	yr1	yr2	yr3	yr4	%	yr1	yr2	yr3	yr4	%
Number of cases	43	60	114	123		245	212	153	155	
<b>Complication</b>					<b>%</b>					<b>%</b>
Death	0	0	2	1	<b>0.9</b>	2	3	2	2	<b>1.2</b>
Intra-aortic balloon	0	0	3	2	<b>1.5</b>	9	4	7	6	<b>3.4</b>
Tamponade	0	0	0	0	<b>0.0</b>	2	2	0	0	<b>0.5</b>
Pacemaker	0	1	0	0	<b>0.3</b>	0	4	0	2	<b>0.8</b>
Myocardial infarction	0	0	1	0	<b>0.3</b>	2	1	0	2	<b>0.6</b>
Ventricular arrhythmia	0	0	2	0	<b>0.6</b>	3	3	6	2	<b>1.8</b>
Prolonged inotropes	6	3	20	33	<b>18.2</b>	37	50	47	48	<b>23.8</b>
Atrial fibrillation	6	4	12	12	<b>10.0</b>	29	25	23	13	<b>11.8</b>
Atrial flutter	1	0	1	1	<b>0.9</b>	4	3	0	2	<b>1.2</b>
Prolonged ventilation	0	0	3	2	<b>1.5</b>	4	2	8	1	<b>2.0</b>
Pneumothorax/effusion	0	0	1	0	<b>0.3</b>	1	4	2	0	<b>0.9</b>
Chest infection	0	1	1	0	<b>0.6</b>	3	0	1	1	<b>0.6</b>
Laparotomy	0	0	1	1	<b>0.6</b>	0	0	0	1	<b>0.1</b>
Gastroduodenal bleeding	0	0	0	1	<b>0.3</b>	3	1	2	2	<b>1.0</b>
Dialysis	0	0	3	2	<b>1.5</b>	0	4	8	6	<b>2.3</b>
Creatinine doubling	0	0	1	3	<b>1.2</b>	5	2	2	1	<b>1.3</b>
Cerebrovascular accident	0	0	3	1	<b>1.2</b>	3	1	1	1	<b>0.8</b>
Transient ischemic attack	1	0	1	2	<b>1.2</b>	1	1	0	0	<b>0.3</b>
Postoperative confusion	0	0	2	0	<b>0.6</b>	0	0	0	0	<b>0.0</b>
Peripheral neuropathy	0	0	1	0	<b>0.3</b>	0	0	0	0	<b>0.0</b>
Serious wound infection	0	0	2	0	<b>0.6</b>	0	2	0	0	<b>0.3</b>
Resuturing of wound	0	0	1	0	<b>0.3</b>	0	0	0	0	<b>0.0</b>
Endocarditis	0	0	0	0	<b>0.0</b>	0	3	0	0	<b>0.4</b>
Septicaemia/bacteraemia	0	0	1	3	<b>1.2</b>	3	1	4	2	<b>1.3</b>
Sternotomy for bleeding	0	0	2	1	<b>0.9</b>	1	2	1	0	<b>0.5</b>

**Figure 9: Ventilation**



of the diseased aorta during surgery.<sup>13</sup>The complication rates in other systems are too low to derive any trends.

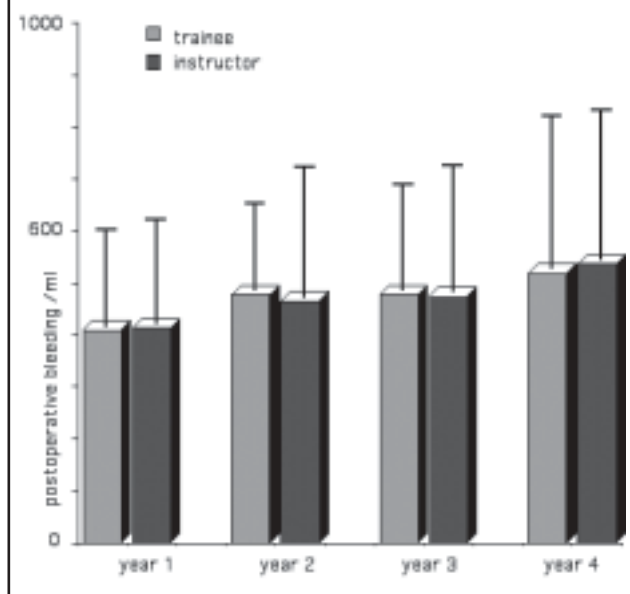
The training period under study by no means represented the entirety of the trainee's program. Whereas dexterity was easily seen to improve during these initial four years, more complex tasks such as patient selection and post-operative management are more difficult to evaluate and require a longer period to gain. During the study period the instructor increasingly allowed for the trainee to take decisions without prompting. The trainee was allowed to operate with junior assistance at a more advanced stage of his career. Moreover the trainee was exposed to other surgical methods, both locally and abroad.

In summary graft time was measured as an index of competence. During the same study period VLAD plots were utilised to demonstrate the changing practice of the trainee as it came to resemble more closely that of his instructor. This progress was achieved without jeopardising patient outcome.

## Conclusion

Training our future surgeons is not an easy task and requires the co-operation of all members of the working team. It is a task that requires us always to put the patient's interests first and at the same time allow the trainee an increasing role. But when properly performed training can be one of the most rewarding aspects of our surgical career.

**Figure 10: Postoperative bleeding**



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