

# Coronary Artery Surgery Results 2000

Yukiyasu Sezai, MD, Yukihiko Orime, MD, and Saeki Tsukamoto, MD

**We have reported on changes in the nature and outcome of coronary artery bypass surgery over the past 30 years, focusing on surgery performed last year, from January 1 to December 31, 2000. The operative mortality for patients who underwent only coronary artery bypass surgery was 2.75% in 2000. Mortality for initial elective surgery was 1.73%. These are the best results obtained since surveys were started. The percentage of elderly patients undergoing coronary artery bypass surgery is rising annually. In 2000, 40.8% of patients were aged 70 years or older and 5.3% were aged 80 years or older. Mortality in elderly patients undergoing initial elective surgery is decreasing, with a mortality of 2.5% for patients aged 70 years or older and 2.9% for patients aged 80 years or older. Off-pump coronary artery bypass grafting was performed on 3,356 patients in 2000. Median sternotomy was used in the majority of cases, with 2,988 patients undergoing surgery by this approach. Use of minimally invasive direct coronary artery bypass (MIDCAB) peaked in 1998 but is becoming less common, with only 280 patients undergoing this procedure in 2000. (Ann Thorac Cardiovasc Surg 2002; 8: 241–7)**

**Key words:** coronary artery bypass grafting (CABG), arterial graft, off-pump CABG, minimally invasive direct coronary bypass grafting (MIDCAB)

## Introduction

The Japanese Association for Coronary Artery Surgery (JACAS) has been conducting surveys of the status of coronary artery surgery since 1970, the days of its predecessor organization.<sup>1-4)</sup> The focus of the most recent survey was coronary artery surgery performed in the year from January 1 to December 31, 2000. Completed questionnaires were returned by 287 institutions with cardiac surgery departments. This report describes a summary of advances in coronary artery surgery in Japan in the twentieth century based on the status of coronary artery surgery over the past years and a review of the results of previous surveys.

Operative mortality is defined as any death within 30 days after the day of surgery. Operative mortality by pa-

tient characteristics was examined by  $\chi^2$  statistics.

## Total Number of Coronary Artery Bypass Surgery

A total of 13,891 patients underwent coronary artery bypass surgery in 2000. Of these, 13,548 underwent coronary artery bypass grafting (CABG) only. The other 343 patients underwent additional procedures for myocardial infarction or other complications at the same time. Between 1970 and December 31, 1999, coronary artery bypass surgery was performed on 148,833 patients. In recent years, a total number of coronary artery bypass surgery drastically increased. In the past five years, 67,622 patients have undergone bypass surgery. That is 1.4 times higher than in the previous five years, when 48,612 patients had bypass surgery (Fig. 1).

## Coronary Artery Bypass Grafting (CABG)

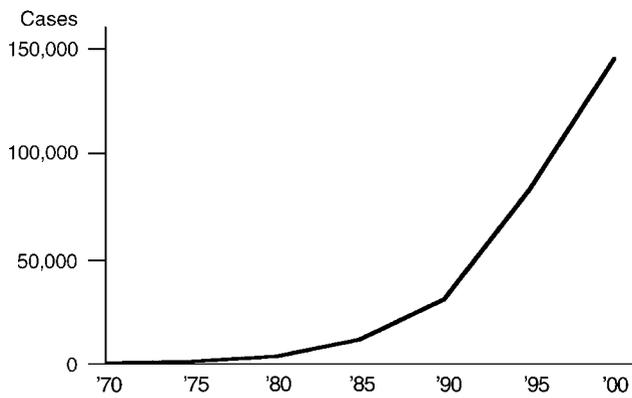
### Change in number of grafts in CABG

Of 65,461 patients who underwent only a CABG in the last five years, one graft was used in 14.1%, two grafts in

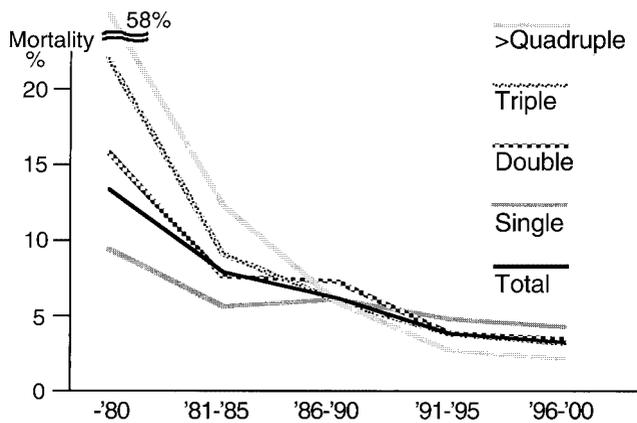
---

*Form the Second Department of Surgery, Nihon University School of Medicine, Tokyo, Japan*

Received May 24, 2002; accepted for publication June 24, 2002. Address reprint requests to Yukihiko Orime, MD, PhD: 30-1 Oyaguchi, Kami-machi, Itabashi, Tokyo 173-8610, Japan.



**Fig. 1.** Total number of coronary artery bypass surgery.

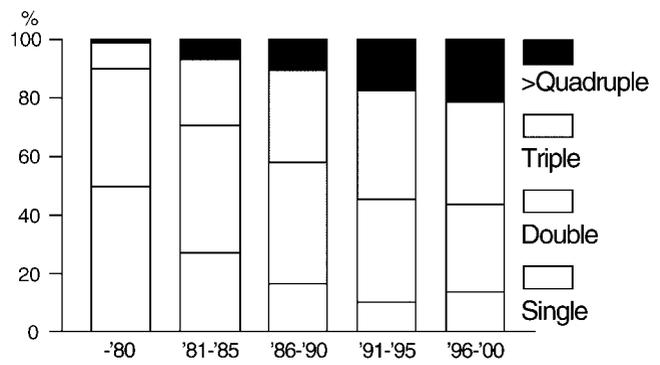


**Fig. 3.** Change in operative mortality according to number of grafts.

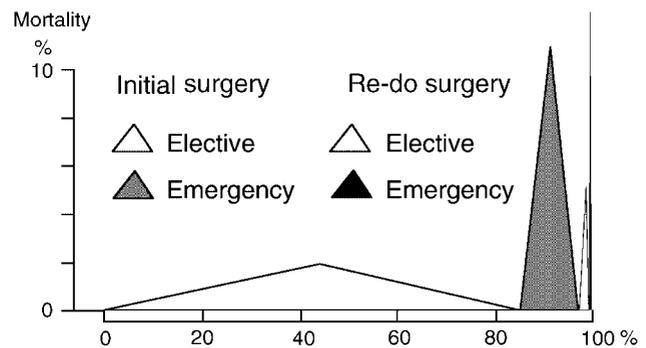
29.4%, three grafts in 35.4%, and four or more grafts in 21.1%. The mean number of grafts was 2.63, where four or more grafts are counted as four grafts. This is 0.06 higher than the previous mean of 2.57 grafts. Prior to 1981, approximately half of bypass operations were single-vessel, and single- and double-vessel bypass accounted for 90% of cases. Since then, there has been an annual trend toward multivessel bypass. However, the most recent survey shows that although four-vessel bypass is becoming more common, the percentage of patients undergoing single-vessel bypass, which had been falling, has again increased (Fig. 2).

**Change in operative mortality according to number of grafts**

Figure 3 shows operative mortality for coronary artery bypass for each period. The operative mortality prior to 1981 was 13.4%. This fell over each subsequent five-year



**Fig. 2.** Change in number of grafts in CABG.



**Fig. 4.** Outcome according to urgency and times of surgery.

period to 7.9%, 6.9%, 3.7%, and to 3.2% between 1996 and 2000. Previously, the mortality rate rose as the number of vessels bypassed increased. However, the reverse was the case from 1986 to 1990, and from the 1990s, single-vessel bypass had the highest mortality. In the past five years, mortality was 4.4% for single-vessel bypass, 3.6% for double-vessel bypass, 3.1% for triple-vessel bypass, and 2.2% for four-vessel bypass.

**Outcome according to urgency and times of surgery**

Surgical outcomes over the last five years (1996-2000) are shown in Fig. 4. The horizontal axis shows the type of surgery (that is, whether it was elective or emergency and whether it was initial or repeat) and the percentage of patients who underwent each type of surgery. The vertical axis shows the mortality for each type of surgery. The operative mortality was 2.0% for initial elective surgery, 11.1% for initial emergency surgery, 5.1% for repeat elective surgery, and 15.7% for repeat emergency surgery. Initial emergency surgery accounts for a large

No. of bypass	Mortality			
	0-2.9%	3.0-4.9%	>5.0%	
	Single	Double	Triple	>Quadruple
1VD				
2VD				
3VD				
LMT only				
LMT+1VD				
LMT+2VD				
LMT+3VD				

**Fig. 5.** Outcome according to the number of diseased vessels and number of grafts.

VD: vessel disease, LMT: left main trunk

number of patients and therefore has a marked effect on surgical outcome overall. The same trend was evident in previous surveys. Incidentally, the operative mortality for initial elective surgery was 1.7% last year (2000).

**Outcome according to number of diseased vessels and number of grafts**

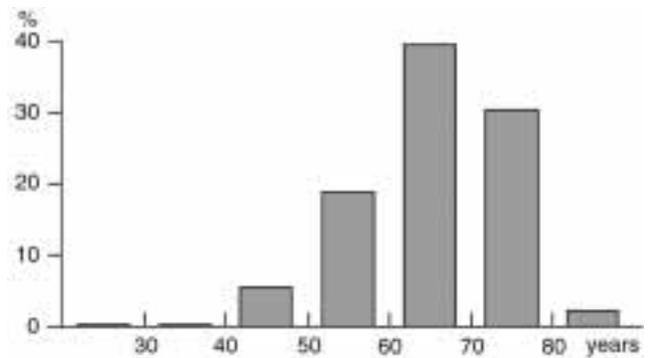
Figure 5 compares the surgical outcome according to the number of diseased vessels, laid off along the vertical axis, and the number of grafts, plotted horizontally. Throughout the last five years, mortality was low in patients in whom complete revascularization was possible and tended to be high in patients in whom complete revascularization was not achieved. In other words, the outcome was poorest for single-vessel bypass and best for multivessel bypass. Four-vessel bypass for single-vessel disease was performed in only 12 patients. The mortality rate of 8.3% was due to the death of one patient.

**Age distribution**

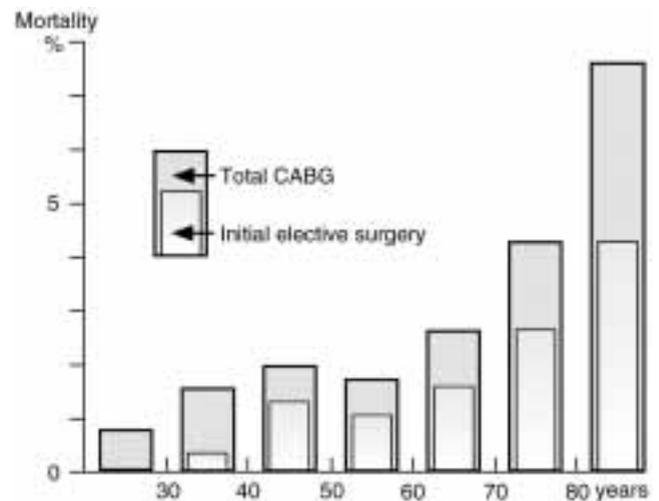
A survey of outcome according to age was started in 1997. The results presented are a summary for the past four years. Examination of age distribution in decades shows that most patients were in their 60s, followed by those in their 70s. A total of 37.6% of all surgeries was performed on patients aged 70 years or older (Fig. 6).

**Surgical outcome according to age**

Figure 7 shows operative mortality for each period. The results for all of the patients are shown in the background, and the results for initial elective surgery are shown in the foreground. Mortality increased once patients were over 70 years of age. The mortality for initial elective



**Fig. 6.** Age distribution.

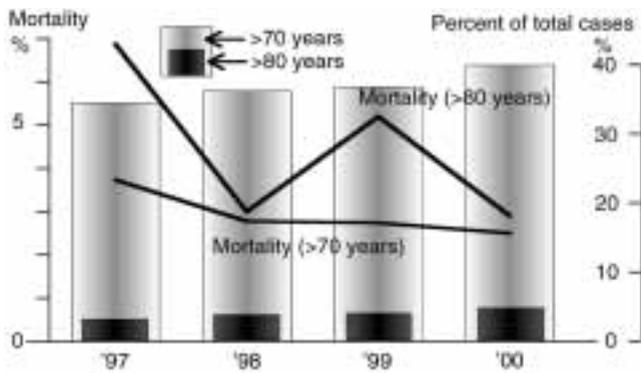


**Fig. 7.** Surgical outcome according to age.

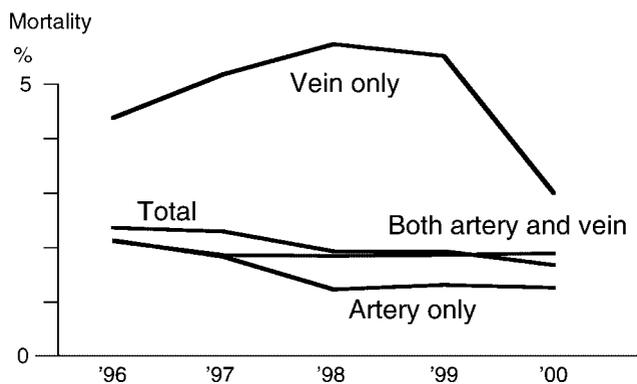
surgery was 2.7% for those in their 70s and 4.3% for those in their 80s.

**Surgical outcome in elderly patients (initial elective surgery)**

Focusing on the growing number of elderly patients, this slide shows the outcome of initial elective surgery for each decade in patients aged 70 years or older. The bar shows the percentage of patients, and the chain lines show operative mortality. The percentage of patients aged 70 years or older is increasing annually, reaching 33.8% in 1997 and 39.4% in 2000. The proportion of elderly patients aged 80 years or older has also risen annually over the past four years, increasing from 2.8 to 4.3%. Operative mortality is decreasing, falling from 3.7% in 1997 to 2.5% in 2000 in patients aged 70 years or older and from 6.9% in 1997 to 2.9% in 2000 in patients aged 80 years or older. Incidentally, in 2000, the mortality for emer-



**Fig. 8.** Surgical outcome in elderly patients (initial elective surgery).



**Fig. 10.** Surgical outcome according to graft (initial elective surgery).

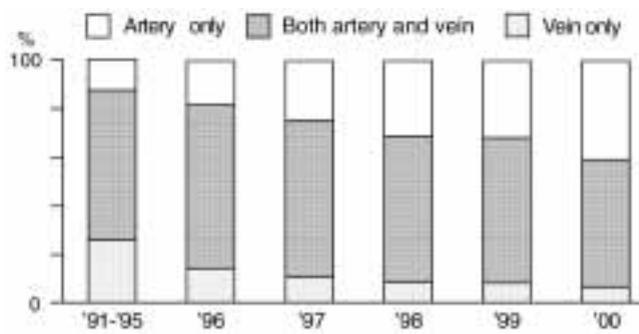
gency and redo surgery combined was 40.8% in patients aged 70 years or older and 5.3% in patients aged 80 years or older (Fig. 8).

**Graft selection (initial elective surgery)**

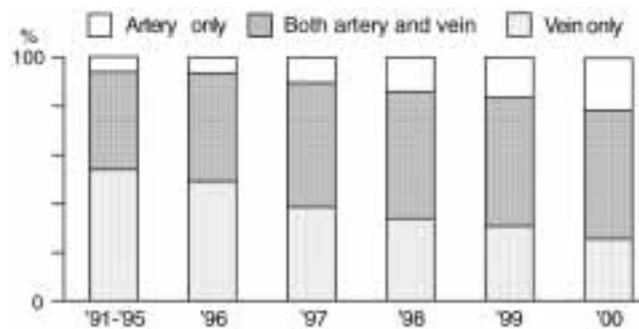
Figure 9 shows changes in graft selection for initial elective surgery. The percentage of patients receiving artery grafts is growing each year. Between 1991 and 1995, 54.2% of single-vessel bypass operations were performed with artery grafts. In 2000, this increased to 85.6%. A total of 48.1% of double-vessel bypass operations were also performed with artery grafts only. The use of artery grafts only in initial elective surgery continues to increase.

**Surgical outcome according to graft (initial elective surgery)**

Figure 10 shows changes in surgical outcome according to graft for initial elective surgery. Since 1996, there has been a steady decrease in mortality among patients as a



**Fig. 9.** Graft selection (initial elective surgery).



**Fig. 11.** Graft selection (initial emergency surgery).

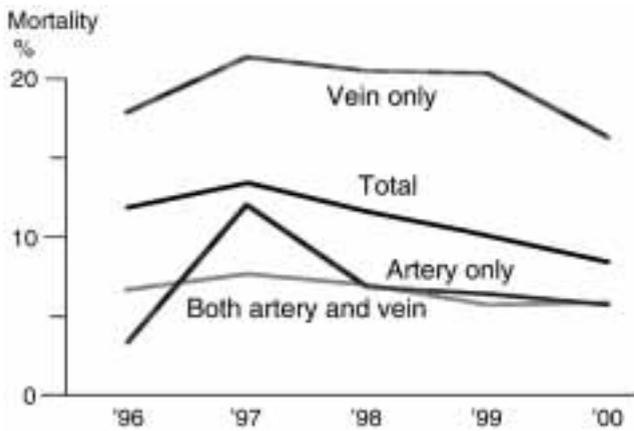
whole. Operative mortality was 1.7% for initial elective surgery in 2000. Mortality was 1.3% for bypass with artery grafts only and 1.9% for bypass with both artery and vein grafts. This was virtually the same as in the previous year. In 2000, the mortality for surgery using vein grafts only decreased from 5.5% to 3.0% in 2000. However, the outcome of surgery with vein grafts only remained poor.

**Graft selection (initial emergency surgery)**

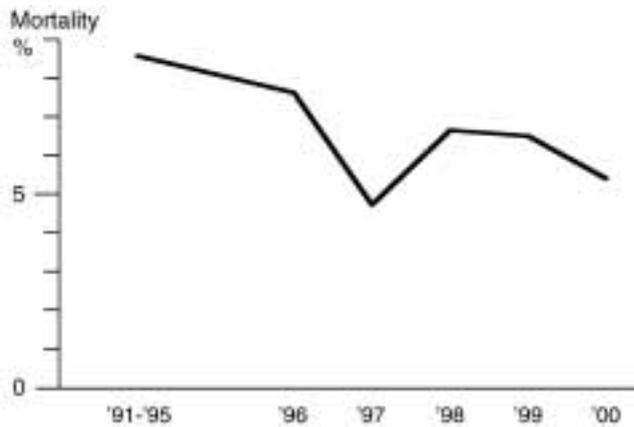
Changes in graft selection for initial emergency surgery are shown in Fig. 11. Between 1991 and 1995, 55% of operations were performed with vein grafts only. However, the use of vein grafts is decreasing. In 2000, the percentage of patients who received only vein grafts decreased to 25.9%. In contrast, use of only artery grafts increased to 21.3%.

**Surgical outcome according to type of graft (initial emergency surgery)**

Figure 12 shows changes in surgical outcome according to type of graft for initial emergency surgery. Operative mortality for initial emergency surgery was 8.7% in 2000, which was exactly five times that for elective surgery.



**Fig. 12.** Surgical outcome according to type of graft (initial emergency surgery).



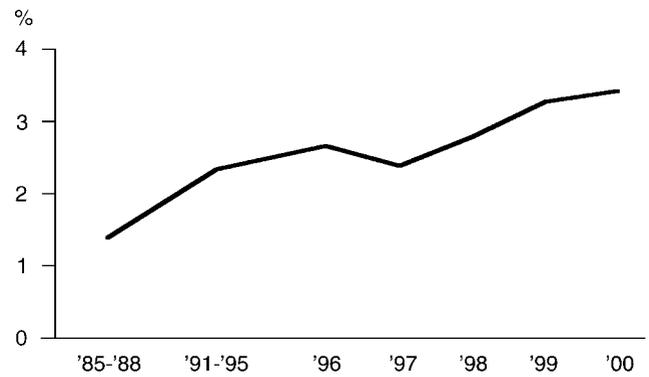
**Fig. 14.** Mortality for redo surgery.

Mortality was 5.9% for surgery with artery grafts only and 6.0% for surgery with both artery and vein grafts. This was virtually the same as in the previous year. Mortality for bypass with vein grafts only decreased from 20.2% to 16.3%. However, the outcome of surgery with vein grafts only was poor, as was the case with elective surgery.

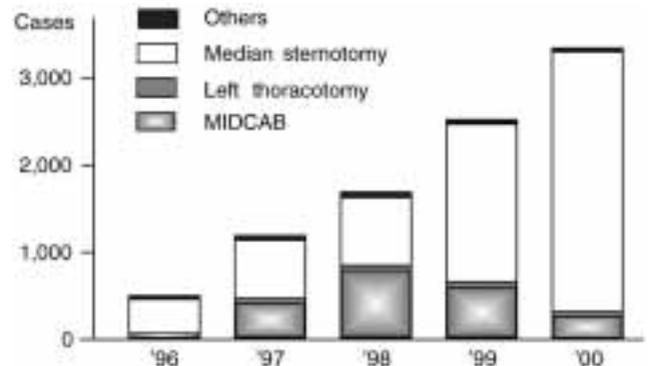
## Redo Surgery

### Percentage of redo surgery

Figure 13 shows changes in the percentage of redo operations among coronary artery bypass operations as a whole. Redo surgery accounted for 1.4% of bypass operations from 1985 (15 years ago) to 1988, but this rose to 5.4% in 2000.



**Fig. 13.** Percentage of redo surgery.



**Fig. 15.** Off-pump coronary artery bypass grafting.

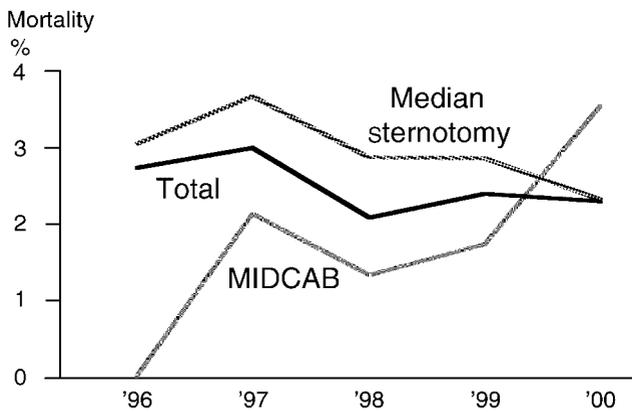
### Mortality for redo surgery

Changes in mortality for redo surgery from 1991 onward are shown in Fig. 14. Mortality was 8.6% between 1991 and 1995, but decreased to 5.4% in 2000. This is almost double the mortality for initial surgery, which was 2.8%.

## Off-pump CABG and Minimally Invasive Direct Coronary Artery Bypass

### Off-pump CABG

Figure 15 shows changes in off-pump CABG. Off-pump CABG has become more common since 1996. The most recent survey shows a further increase, with 3,356 patients undergoing this type of bypass. The number of patients undergoing off-pump bypass using median sternotomy has increased annually, rising from 1,832 in the previous year to 2,988 in 2000. This is an increase of 1.6 fold. However, CABG via a small left thoracotomy, or minimally invasive direct coronary artery bypass (MIDCAB), has become less common since peaking in 1998. Last year, only 280 patients underwent this proce-



**Fig. 16.** Surgical outcome for off-pump CABG.

ture, less than half the number -632- in the previous year. In the most recent survey, 107 facilities performed off-pump CABG on 10 or more patients in 2000, in contrast with only 7 facilities that performed MIDCAB on 10 or more patients.

**Surgical outcome for off-pump CABG**

Figure 16 shows changes in the surgical outcome of off-pump CABG. Operative mortality was 2.3% for off-pump CABG overall last year. There has been no major change in mortality over the past five years, which ranged from 2.1% to 3.0%. Operative mortality for off-pump CABG using median sternotomy has decreased recently; last year, mortality was 2.4%. However, operative mortality for MIDCAB has risen sharply, increasing to 3.57% last year.

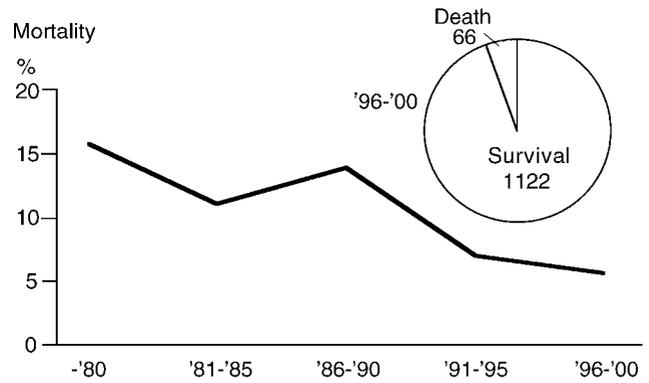
**Post-myocardial Infarction Complication Surgery**

**Surgery for left ventricular aneurysms**

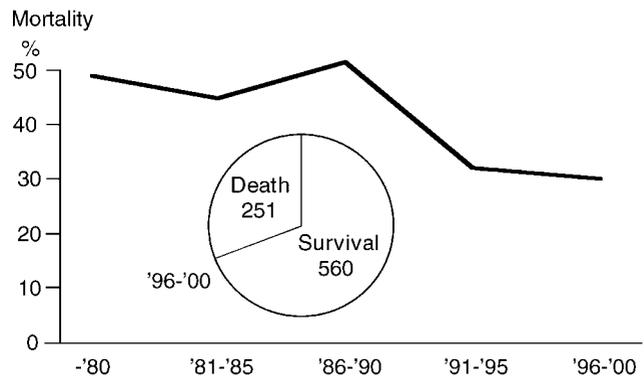
Surgical outcome for myocardial infarction as a complication is shown in Fig. 17. The pie chart shows outcome over the past five years, and the chain line shows changes in mortality over each five-year period. Surgery for left ventricular aneurysms was performed on 1,188 patients in the last five years. The operative mortality was 5.6%. The outcome of this type of surgery has always been better than for other complications, but it has improved further.

**Surgery for ventricular septal perforation (VSP)**

Surgery for ventricular septal perforation (VSP) was performed on 811 patients in the last five years, with an operative mortality of 30.9%. Mortality remained at around 50% until 1990 but decreased to 32.9% between 1991



**Fig. 17.** Surgery for left ventricular aneurysms.



**Fig. 18.** Surgery for VSP.

and 1995 and fell further in the most recent survey. However, VSP has the lowest survival rate after cardiac rupture (Fig. 18).

**Surgery for left ventricular papillary muscle rupture**

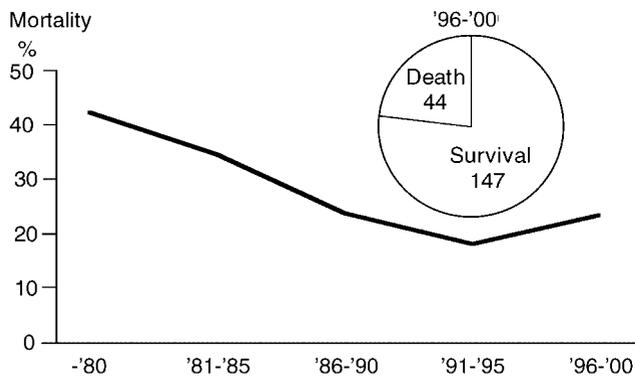
Surgery for left ventricular papillary muscle rupture was performed on 191 patients in the last five years. It is less common than other complications. Mortality was 18.5% between 1991 and 1995 and higher in 2000, at 23.0% (Fig. 19).

**Surgery for cardiac rupture**

Three hundred and ninety six patients underwent surgery for cardiac rupture. Prior to 1981, most patients did not survive. Mortality has decreased each year since then and is currently 36.9%. However, this complication has the highest mortality (Fig. 20).

**Conclusions**

In conclusion, the operative mortality for patients who



**Fig. 19.** Surgery for left ventricular papillary muscle rupture.

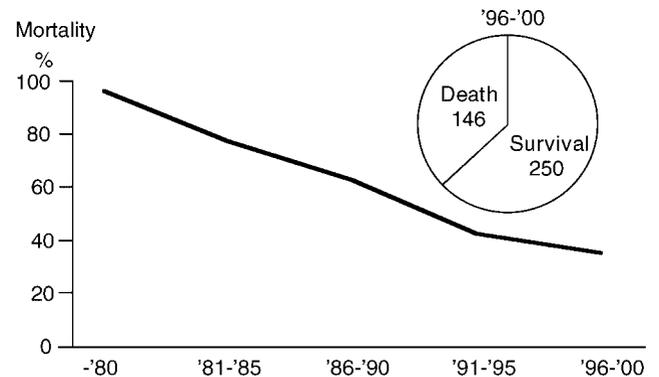
underwent only coronary artery bypass surgery was 2.75% in 2000. Mortality for initial elective surgery was 1.73%. These are the best results obtained since surveys were started.

The percentage of elderly patients undergoing coronary artery bypass surgery is rising annually. In 2000, 40.8% of patients were aged 70 years or older and 5.3% were aged 80 years or older. Mortality in elderly patients undergoing initial elective surgery is decreasing, with a mortality of 2.5% for patients aged 70 years or older and 2.9% for patients aged 80 years or older.

Off-pump CABG was performed on 3,356 patients in 2000. Median sternotomy was used in the majority of cases, with 2,988 patients undergoing surgery by this approach. Use of minimally invasive direct coronary artery bypass peaked in 1998 but is becoming less common, with only 280 patients undergoing this procedure in 2000.

### Acknowledgments

We would like to take this opportunity to thank the doctors at all of those 287 institutions for taking part in this survey.



**Fig. 20.** Surgery for cardiac rupture.

This report would not have been possible without the assistance of many institutions and doctors. Unfortunately, however, fewer and fewer institutions are returning questionnaires. Future cooperation would be greatly appreciated as the survey is an important means of determining the status of coronary artery surgery in Japan. Finally we also thank Ms. Eiko Yuzawa and Ms. Yukiko Sugiyama, the secretaries of our department, without whose invaluable assistance, this report could not have been completed.

### References

1. Sezai Y, Kitamura S, Harada Y, et al. Results of coronary artery surgery in Japan. *Rinsho Kyobu Geka* 1989; **9**: 53–62.
2. Sezai Y, Hasegawa T, Kitamura S, et al. Surgical management of acute myocardial infarction in the 24 hours—the Japanese experience. In: D'Alessandro LC ed.; *Heart Surgery* 1991. Rome: Casa Editrice Scientifica Internazionale, 1991; pp 417–24.
3. Sezai Y. Coronary artery surgery status in Japan. In: Sazai Y ed.; *Advances in coronary artery surgery*. Tokyo: Axel Springer Japan, 1997; pp 3–12.
4. Sezai Y, Tsukamoto S. Coronary artery surgery results 1996. *Ann Thorac Cardiovasc Surg* 1998; **4**: 103–6.