

Changing Trends in Valve Surgery in Europe: 1991-2000

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Background and aim of the study: This study sought to elaborate the changing trends in valve surgery in Europe during the 1990s.

Methods: The databases of different national surgical societies, registries and governments and international organizations were consulted and the data obtained were analyzed.

Results: The population of Europe (excluding Russia, CIS and Turkey) increased by 2.29%, from 509.67 million in 1991 to 519.15 million in 2000. During this period, the volume of cardiac surgery increased in Europe by 101% to 413,520 operations (797 per 10⁶ population). The volume of valve surgery increased by 63% to 85,076 (164 per 10⁶ population). The largest volumes of valve surgery were performed in Germany, France, UK, Italy and Spain. The increase in valve surgery volume was maximum in the Baltic states (+287%) and least in Scandinavia (+30%). Valve surgery volume per center per year changed from 139 in 1991 to 140 in 2000. The increase in overall valve surgery volume was sustained by an increase in subsets of octogenarian patients, valve surgery combined with coronary artery surgery, and increased productivity of the emerging economies of countries such as the Czech Republic, Hungary and Poland. Valve surgery as a proportion of cardiac surgery in

Europe changed from 25.95% in 1991 to 21% in 2000. In 2000, valve surgery with combined procedures constituted 6.7% of total cardiac surgical volume, but 32% of valve surgical output in Europe. Mechanical valves have continued to dominate and were used in 77% of cases in 2000. Increased use of bioprostheses in the elderly subset among affluent economies was balanced by an increased use of mechanical prostheses in younger patients in emerging facilities in the East and South. The capital-intensive innovations (viz. robotic valve surgery, minimally invasive valve surgery, bioengineered valves) found niches only in some West European centers. Catheter-based procedures did not fulfil their promise. Balloon aortic valve dilatation investigations decreased drastically by the end of the decade, and balloon mitral dilations were considerably reduced in number. Conservative aortic valve surgery is not yet practiced widely across Europe, while mitral repair has become widely accepted in clinical parlance.

Conclusion: Despite the greater political and economic integration of Europe, the pattern of valve surgery continues to remain extremely diverse within the continent.

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Although several historical 'firsts' in cardiac valve surgery - for example, Souttar's mitral valvotomy, Tuffier's aortic valvotomy, homografts and valve reconstructions - took place in Europe, the overall productivity paled against the prolific output from North America. Since the fall of the Berlin wall, the Balkan war and the first expansion of the European Union,

there has been a dramatic restructuring of Europe. Likewise, both quantitative and qualitative changes in cardiac surgery took place during the last decade of the twentieth century. In this respect, the present study sought to elaborate on the changing trends in cardiac valve surgery in Europe during the 1990s.

Materials and methods

The databases of different national surgical societies and governments and international organizations (CTS.net, STS National Cardiac Surgery database, European Heart Institute, Global Cardiovascular Network, etc.) were consulted and the data obtained

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analyzed. Different working group reports of supranational bodies (viz. European Society of Cardiology, European Association of Cardiothoracic Surgery, etc.) and national societies (viz. Societa Italiana di Chirurgia Cardiaca of Italy, Spanish Cardiovascular Surgery annual reports, etc.) were consulted. Some countries maintain their own national registries (e.g. UK Heart Valve Registry) which were consulted for verification of harvested data. Websites of national societies of Cardiology and Cardiothoracic Surgery were studied. Historic population data were validated by consulting www.library.uu.nl/wesp/populstat (1). Relevant economic data were harvested and verified from the World Bank, International Monetary Fund, International Labor Organization, and the Organization for Economic Cooperation and Development (OECD) (2).

Harvested data focused on the adult cardiac valve surgical output which comprised isolated valve surgery and valve surgery with associated cardiac procedures. Valve surgery performed in adults to treat congenital heart disease was included in the analysis. However, data available for valve surgery in the pediatric age group were harvested under the category of pediatric and congenital heart surgery, and excluded from this analysis.

In addition to data from Europe being analyzed as a whole, the data were further analyzed by groups of countries, namely:

Scandinavia (Denmark, Greenland, Finland, Iceland, Norway, Sweden)

Baltic states (Estonia, Latvia, Lithuania)

Balkan states (Albania, Bosnia and Herzegovina, Bulgaria, Croatia, Macedonia, Serbia, Slovenia)

Benelux (Belgium, Luxembourg, Netherlands)

Mediterranean (Cyprus, Greece, Italy, Malta, Portugal, Spain)

Central (Germany, Austria, Switzerland)

West (France, Ireland, Monaco, UK, Liechtenstein, Andorra)

Eastern states (Czech Republic, Hungary, Poland, Romania, Slovakia)

Russia and CIS states (Armenia, Azerbaijan, Belarus, Georgia, Moldova, Ukraine)

There is commonality in geographical, historical, political and economic factors and also in the epidemiology of these groups. Diversity of technical infrastructure shows less swing within the group. Social development and healthcare delivery systems are more similar within each group. Thus, the comparisons are more meaningful and the planning and economics for strategies for further development are likely to be more confluent for each region.

Annual data harvested from Russia and CIS states and Balkan states had been inconsistent due to geopolitical reasons. Data from Balkan states could be harvested historically and analyzed. End-point data from Russia and CIS states were available and included overall trend analysis, but were excluded from group-wise annual trend assessments.

Results

Population

The population of Europe (excluding Russia, CIS and Turkey) increased by 2.29%, from 509.67 million in 1991 to 519.15 million in 2000. If Russia, CIS and Turkey are included, this percentage increase was only 1.6%, from 798.958 million in 1991 to 811.356 million in 2000. The total population decline occurred in the Baltic and Balkan states, Russia and CIS states, and middle European states (Czech Republic, Hungary, Poland, Romania, Slovakia). The total population increase was greatest in the Mediterranean states - by 6.3% - from 175.023 million in 1991 to 186.022 million in 2000.

Octogenarians

The increase in prevalence of elderly patients, and especially in octogenarians with their degenerative aortic valve disease, has contributed to valve surgery output. Though conventional wisdom associates graying of the population with a better economy, the relationship was not linear. The increase in very old population (aged ≥ 80 years) was noticed most in Scandinavia. In 2000, this very old population constituted the percentage of population as: Europe 15%, Scandinavia 20.8%, Baltic states 13%, Balkan states 9.9%, Benelux 17.3%, Mediterranean 15.1%, Central 17.6%, Western 19%, Middle 12.6% and Russia and CIS states 10.1%. From 1998, the proportion of octogenarians and older people was largest in Northern Europe, followed by Western Europe and Southern Europe. The three countries with the highest proportions of the octogenarians and older in 1998 were Sweden (4.8%), Norway (4.2%) and the UK (4.1%).

At the national level in Europe, 3.1 million people in Germany and 3.0 million in the Russian Federation are currently octogenarians or older. By 2050, 12 countries in the world are projected to have more than 10% of their population aged ≥ 80 years. These include Italy, Austria, Belgium, China, Germany, Greece, Japan, Netherlands, Singapore, Spain, Sweden and Switzerland.

The changing population demographics can only partially explain the changing character of valve surgery patients volume in Europe, however.

Resources

The gross national income (GNI) per capita in Europe is surprisingly lower than expected. The mean GNI-purchase power parity (in \$US per capita per annum; GNI-PPP) changed from 11,184 in 1991 to 18,697 USD in 2000 (excluding Turkey, Russia and CIS). Taking a closer look, in 2000, Benelux was the most affluent (32,930 \$US) followed by Central European countries (27,233 \$US), Scandinavia (26,826 \$US) and the West (24,497 \$US), all of which were far ahead of other regions.

The total number of cardiac surgical centers increased from 384 in 1991 to 614 in 2000. In 1991, CTS.net did not exist, while the European Association for Cardiothoracic Surgery (EACTS) had only 502 members. The overall number of cardiac surgeons in Europe was estimated to be ~ 1,000 in 1991. In 2000, CTS.net enlisted 3,535 European cardiothoracic surgeons, when the membership of EACTS was 1,400. The estimated number of cardiac surgeons in Europe was ~3000. Changes in productivity in valve surgery, when viewed against the changes in the resources, appeared impressive (Fig. 1).

Surgical output

The annual volume of valve surgery increased in Europe by 63%, from 52,253 in 1991 (at the rate of 103 per 10⁶ population) to 85,076 in 2000 (164 per 10⁶ million population). If Turkey was included in the Mediterranean region, this output changed to 87,229 (149 per 10⁶ population). During this period, the annual volume of cardiac surgery increased in Europe by 101% to 413,520 (797 per 10⁶ population) and the annual volume of coronary artery surgery increased by 107% to 235,619 (454 per 10⁶) in 2000 (Fig. 2).

In absolute numbers, the valve surgery output of France, Germany, UK, Italy and Spain have always been the most prolific in Europe. In 2000, the West, Central and the Mediterranean regions were the most productive regions (Fig. 3). Over the decade, the increase in annual volume of valve surgery output was maximum in the Baltic states (by 287%), followed by the Middle European states (116%), Balkan states (113%), Central Europe (88%), West (53%), Mediterranean (38%) and Benelux (31%), and was least in Scandinavia (by 30%).

In 2000, the frequency of valve surgery in terms of numbers of operations per million population was the

Valve surgery in Europe : Productivity vs Resources

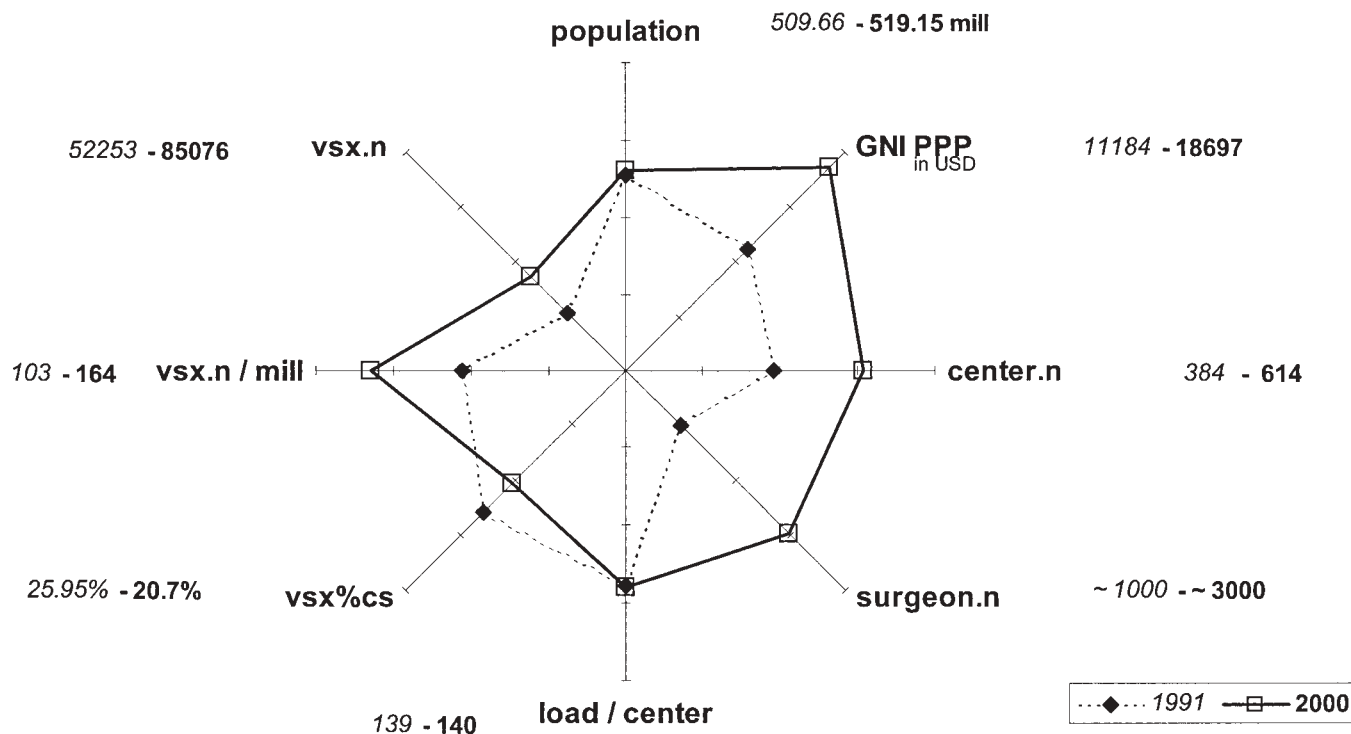


Figure 1: Productivity versus resources of valve surgery in Europe in 1991 and 2000. Vsx.: Valve surgery; n: Number; n/mill: Number per million population; VSX% CS: Valve surgery percentage of cardiac surgery; GNI-PPP in USD: Gross national product-purchase power parity in international US dollars.

highest in Benelux (210), followed by the West (202), Central (199) and Scandinavia (199). During the decade, it changed from 108 to 159 per million in the Mediterranean region, and from 33 to 137 per million in the Baltic states. It has remained low in the Balkan states (30 to 66 per 10⁶) and in the middle European states (43 to 94 per 10⁶) (Fig. 4). France, Switzerland, Finland, Belgium, Austria, Sweden and Hungary were the top seven countries in terms of valve surgery output in numbers per million population (range from 221 to 268).

Valve surgery volume per center per year barely changed, from 139 in 1991 to 140 in 2000. Unlike the pattern of coronary surgery distribution, the regional distribution of valve surgery remained fairly proportional to the distribution of the population (Fig. 5). Regional percentages of valve surgery output of Europe showed minor changes; the major contribution continued to come from Mediterranean, Central and West regions, but only the middle European region showed any significant increase over the decade (Fig. 6).

The percentage of valve surgery patients in the total cardiac surgical population changed from 25.95% in 1991 to 20.7% in 2000. This decline was steeper up until 1997 (18%), at which time it commenced a slow upswing. During the decade, this sector increased in Balkan states (from 26% to 31%) and in the Western states (from 26% to 29%), but decreased in all other regions. In 2000 this sector was largest in the Balkan states (31%), followed by the Mediterranean (30%), West (29%), Baltic states (29%), Middle Europe (22%), Scandinavia (19%) and Benelux (18%), and was lowest in the Central European states (12%) (Fig. 7).

A significant increase occurred in the sector of valve surgery with combined procedures, mostly coronary revascularization and valve surgery among octogenarians. In 2000, valve surgery with combined procedures constituted 6.7% (ranging from 2.7% in Cyprus to 16.5% in Spain) of the cardiac surgical volume, and

about 32% of the valve surgical output in Europe. In Germany, this sector grew from 25% in 1991 to 52% in 2000.

In contrast, in Russia and the CIS states the total valve surgery output was ~4,700 in 2000 (equivalent to 21 per 10⁶ population). Valve surgery as a percentage of the cardiac surgery population was 29% in 2000, while the valve surgery volume per center was 64%.

Prosthesis type

Mechanical valve prostheses continued to dominate the clinical practice. Recently, in some countries (e.g. UK, Austria) the bioprostheses accounted for >50% prevalence. A slow trend towards bioprostheses has been noted in some other countries, including Germany (42%), Italy (~40%) and Spain (~30%). By contrast, in Baltic states, Greece, Hungary and Poland, bioprostheses accounted for <10 to 20%. The overall pattern in 2000 indicated the use of mechanical prostheses in 77% of cases. In 2000, the highest rate of mechanical valve use was noted in the Baltic states (~93%), the Mediterranean (~79%), the Balkan states (~77%) and Middle Europe (~80%). Bileaflet valves have become the preferred mechanical prosthesis, while single-leaflet valves continue to have their followers, but ball valves have registered a decreasing incidence. Although stentless bioprostheses, homografts and the Ross procedure have gained increased clinical acceptance in some centers, stented bioprostheses were favored in the overall pattern among bioprostheses in Europe.

Site of valve surgery

While there has been a steady increase in aortic valve surgery, the aortic:mitral valve surgery ratio has differed widely. Over the decade, the relative quantum of aortic valve surgery increased in northern and the western Europe. In 2000 in the UK, the ratio reached

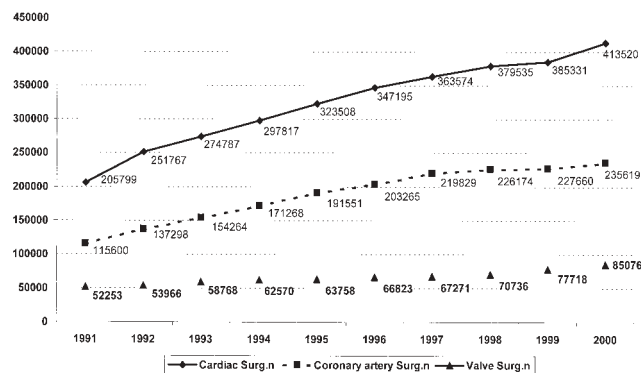


Figure 2: Cardiac surgery, coronary artery surgery and valve surgery output in Europe, 1991-2000.

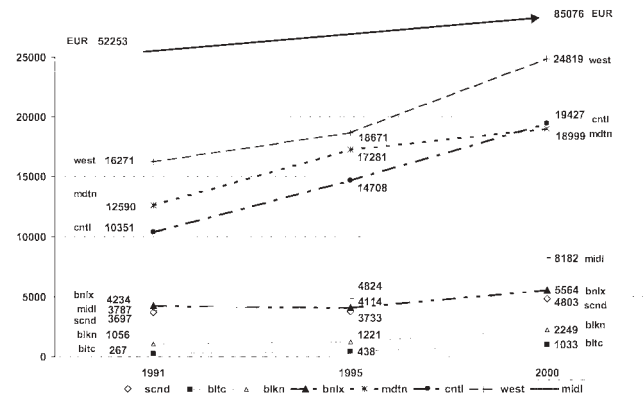


Figure 3: Regional changes in valve surgery output, 1991-2000. Scnd: Scandinavia; Bltc: Baltic; Bnlx: Benelux; Blkn: Balkan; Mdtm: Mediterranean; Cntl: Central; Midl: Middle; Eur: Europe.

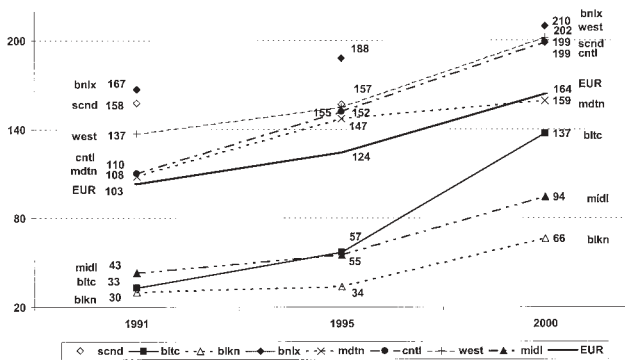


Figure 4: Regional changes in valve surgery in number per million population, 1991-2000. n/million: Number per million population; Scnd: Scandinavia; Bltc: Baltic; Bnlx: Benelux; Blkn: Balkan; Mdtm: Mediterranean; Cntl: Central; Midl: Middle; Eur: Europe.

3:1, in Germany 2.2:1, in Spain 1.7:1, and in Italy 1.3:1. On a very rough assessment, mitral valve surgery tended to be more prevalent in the East and in the South.

Multivalvular surgery

The proportion of double-valve surgery has remained at ~10% of all valve surgery, with only minor regional variations. In the UK, the proportion showed a slow steady decline, from 9.6% in 1991 to 5.8% in 2000. The rate of decline has been much slower in Germany and Spain. The evolution of proportions of double-valve surgery in selected countries is shown in Table I.

The proportion of triple-valve surgery has decreased in Europe during the past decade, but was relatively static at between 0.25% and 2% in 2000.

Valve reconstructions

The enthusiasm of academic centers has not translated into a wider acceptance of conservative aortic valve surgery in clinical practice across Europe. Aortic valve repair, especially for bicuspid aortic valves, reduction aortic annuloplasty for aortic root dilatation and valve-sparing aortic replacements, remain the preserve of a few highly specialized and academic centers. For example, in Germany the proportion of conservative aortic valve surgery of all valve surgery fell from 0.8% in 1991 to 0.64% in 2000.

Mitral valve repair has become widely accepted in clinical parlance. Degenerative mitral valve disease is more frequent than rheumatic lesions in high-volume centers in Northern and Western Europe. Mitral reconstruction accounted for 9.1% of all valve surgery in Germany in 2000.

In 2000, conservative valve surgery accounted for 17% of all valve surgery in Italy, for 9.8% in Germany, and for 4.3% in Spain.

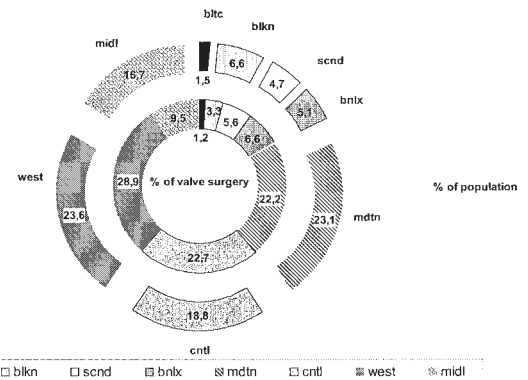


Figure 5: Regional distribution of valve surgery output in 2000. Scnd: Scandinavia; Bltc: Baltic; Bnlx: Benelux; Blkn: Balkan; Mdtm: Mediterranean; Cntl: Central; Midl: Middle; Eur: Europe.

Intervention challenge

Catheter-based procedures were introduced at the beginning of the 1991-2000 decade. However, by the end of the decade the numbers of aortic valve balloon dilatation procedures had decreased drastically, and those of mitral valve balloon dilatation also showed a considerable reduction. This declining trend, notably from the middle of the decade, is shown in Table II (3-7). The disappointing results, the dangers of the procedures and the small size of selected subsets of potential beneficiaries led to a gradual decline in interest for these techniques during the decade.

Mortality

For several reasons, the mortality data were the most difficult to obtain from most national databases. Annual national reports of very few countries (viz. Italy, Spain, Germany, UK Heart Valve Registry, etc.) post their mortality data. Declining mortality has been

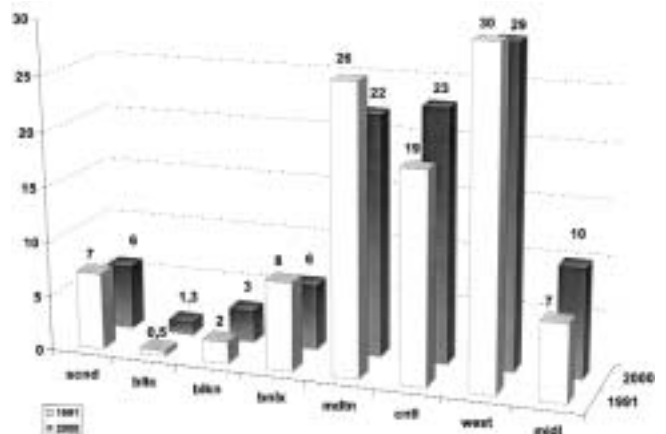


Figure 6: Regional changes in percentage of European valve surgery output, 1991-2000. Scnd: Scandinavia; Bltc: Baltic; Bnlx: Benelux; Blkn: Balkan; Mdtm: Mediterranean; Cntl: Central; Midl: Middle; Eur: Europe.

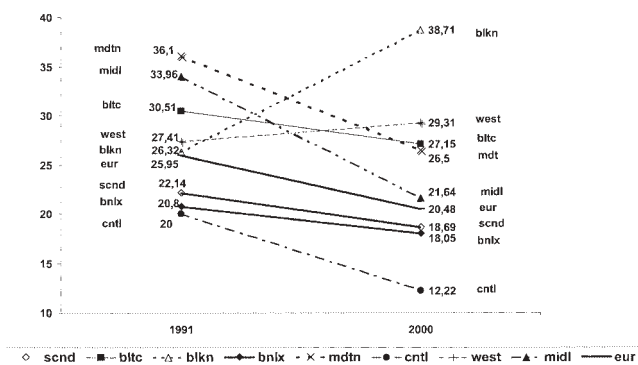


Figure 7: Regional changes in percentage of valve patients in cardiac surgical population, 1991-2000. Scnd: Scandinavia; Bltc: Baltic; Bnlx: Benelux; Blkn: Balkan; Mdt: Mediterranean; Cntl: Central; Midl: Middle; Eur: Europe.

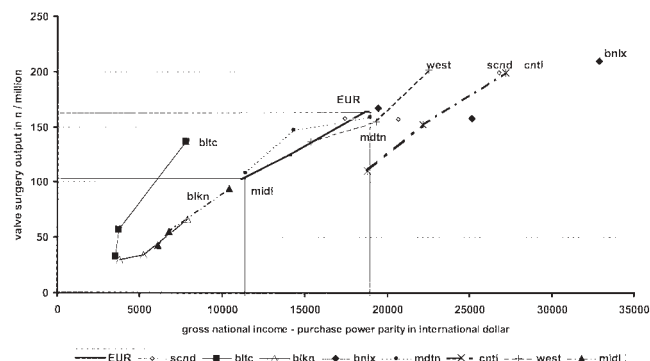


Figure 8: Gross National Income-Purchase Power Parity and valve surgery (n per 10⁶) changes from 1991 to 2000. Scnd: Scandinavia; Bltc: Baltic; Bnlx: Benelux; Blkn: Balkan; Mdt: Mediterranean; Cntl: Central; Midl: Middle; Eur: Europe.e.

reported in some countries, notably the UK Heart Valve Registry. In the absence of mortality data from most countries, it was not possible to assess any pan-European trend.

Discussion

During the decade of 1991 to 2000, there was a modest increase in the volume of valve surgery conducted in Europe. The increase in overall volume was also contributed to by an increase in the subsets of octogenarian patients and valve surgery combined with coronary artery surgery, and also by increased productivity of the 'Tiger' economies of some countries (e.g. Czech Republic, Hungary and Poland).

The rate of increase in absolute numbers of valve

surgery output of the countries and the regions reflected the state of development at baseline in 1991 and the saturation of care delivery in 2000. The West, Central and the Mediterranean regions were the most developed regions in 1991, mostly due to valve surgery volume in France, Germany, UK, Italy and Spain. A lower rate of growth in the Benelux countries and in Scandinavia reflected the saturation of care delivery. The regional growth pattern has led to a regional distribution of valve surgery which is somewhat proportional to the regional distribution of population.

The relative decrease of valve surgery patients in terms of the percentage of total cardiac surgical population during the decade was due to relative increases in other sectors of cardiac surgery, mostly in the coronary artery surgery sector.

Table I: Proportions (%) of double-valve surgery in European countries.

Country	Year									
	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
Italy	14	-	-	-	13	-	-	-	-	10.99
ES	-	-	19	18.6	17.4	16.1	19	18.5	18.4	17.4
DE	11.8	12	11.3	10.98	11.1	11.1	10.2	10.8	10.6	10.7
UK	9.63	9.24	9.51	8.17	8.21	7.95	5.5	9.6	5.76	5.8

Table II: Declining numbers of catheter-based procedures, 1993 to 1997.

Procedure	Year				
	1993	1994	1995	1996	1997
Aortic valve balloon dilatation	510	506	719	307	249
Mitral valve balloon dilatation	3,438	2,622	2,715	2,853	2,630
Pulmonary valve balloon dilatation	594	609	615	817	457

Age

The graying of the population, refinements in surgical techniques and advances in postoperative care contributed to a trend of increased mean patient age. The EuroSCORE study group, based on a sample volume of 5,672 patients in 128 centers in eight European countries between September and December 1995, reported the mean age as 63.0 ± 12.3 years (8). In the UK, the mean age of patients undergoing first-time valve replacement rose from 58.7 years in 1986 to 64.7 years in 1997 (9).

Gender

Most databases have not focused on the prevalence of gender. Anecdotally, men dominate the overall patient population, but the proportion of women has increased in the young rheumatic population and among the very elderly. The referral bias of a country and community does play a role, however. Another report from the EuroSCORE study group (10) did not identify any regional difference of sex distribution between northern and southern Europe, where males accounted for 55.5% and 53.1% respectively of the patient population.

Site and associated surgery

In some countries - for example, the UK - the incidence of mitral valve replacement surgery fell to ~30% in 1997, whereas in Italy the incidence was ~33% in 2000. A recent survey conducted between Q3 in 2001 and Q3 in 2002 by *Cardiovascular News* noted an incidence of mitral valve surgery (replacement and annuloplasty) in 29.8% patients in Western Europe (11). The EuroSCORE study group noted that mitral valve surgery was performed in 41.8% of cases, multivalvular surgery in 14.7%, and associated procedures (coronary revascularization, thoracic aortic surgery) in 25.3% of cases (8). A trend towards more complex combined procedures - mostly with associated coronary revascularization - was also noted. However, this constituted a small proportion (6.7%) of the entire cardiac surgical output, and 32% of the valve surgical output in the present study.

The *Cardiovascular News* survey reported an incidence of 23.7% of combined procedures in valve surgery cases (11). In contrast, in the USA, 50% of all aortic valve operations were reported to be associated with coronary artery surgery (12).

Prosthesis type

About 25 different valve models were used between 1991 and 2000. The UK Heart valve registry noted a 70% prevalence of mechanical prostheses between 1990 and 1997 (9), whereas a prevalence of mechanical prostheses was noted as 59.2% in the period 1991-1995

in the earlier STS study (13). The present study noted an overall prevalence of mechanical prostheses of 77% in 2000 in Europe.

A steady trend towards the use of bioprostheses at the expense of mechanical valves has been noted in UK, Austria and Germany. However, the increased bioprosthesis use in the elderly subset in these affluent economies was balanced by an increased use of mechanical prostheses in younger patients in emerging facilities in the East and South.

Taylor (14) ascribed such preference for bioprostheses to an increase in the surgeons' confidence in the durability of bioprostheses, particularly when implanted in the aortic position, and also to an increase in valve replacement surgery in the elderly.

Such a trend was not noticeable in the overall picture of Europe, and for several reasons. First, the patient population in the newer emerging centers was younger, and this may have prompted the surgeons' preference for mechanical valves. Second, up to 30% of patients who receive a biological valve ultimately require anticoagulants for either a cardiac or a non-cardiac reason. The safety of mechanical valves in elderly patients has also been noted (15). Third, as reoperations in octogenarians have become more frequent, and the hazards for reoperation in that group are higher than hazards of anticoagulation, there may be a valid case for opting for mechanical prostheses in primary valve surgery in patients who are in their early 70s (16). In the UK itself, the reoperation rate (for all valve replacements) was 3% over 15 years, but this carried a mortality of 20% for patients aged >70 years (14). Furthermore, the octogenarians accounted for 13% of general population in the Baltic states and 20.8% in Scandinavia by 1998, yet in 2000 the proportions of mechanical prostheses used were 94% and ~70% respectively in these two countries.

The Euro Heart Survey of the European Society of Cardiology, based on a total of only 5,001 valvular heart disease patients from 92 centers in 25 countries, also noted a shift in the age threshold for mechanical valves, from 65 to 70-75 years (17). However, the present investigation did not identify any validation for the Society's conclusion that bioprostheses were used predominantly, except in eastern Europe.

Mortality

In the absence of any pan-European trend in mortality, the EuroSCORE database and STS National Cardiac Surgery Database currently serve as benchmarks. The EuroSCORE study group noted an early mortality rate of 6.1% (8), while the Euro Heart Survey of the European Society of Cardiology noted an overall operative mortality of 3.8% after interventions in 2001 (18). In Germany, mortality after valve surgery

declined from 5% to 4.1% over the decade, while in the UK in 2000 the overall 30-day mortality for the first operation was 5.6%. The 30-day mortality was generally higher for females, multiple valve replacements and octogenarians, as was also reflected by data from the UK Heart Valve Registry.

Etiology and lesions

The Euro Heart Survey of the European Society of Cardiology had noted that a degenerative etiology was the most frequent cause in Western Europe, while rheumatic disease was a far more frequent reason in Eastern Europe than in other regions. Endocarditis remains a serious concern, and changes in the bacteriology of the condition have been noted in some countries, notably France, where 70% of patients had native valve disease, and almost 30% of these had had previous interventions. Aortic stenosis was the most frequent native valve lesion, followed by mitral regurgitation. In addition to echocardiography, catheterization is still performed in two-thirds of cases for further evaluation. Preoperative coronary angiography is performed in the vast majority of cases. The EuroSCORE study group noted that mitral stenosis was still present in 17% of cases in Europe (8).

Asymptomatic patients

Unlike in the USA, valve surgery for asymptomatic patients with severe aortic or mitral disease is still not adopted in the general practice pattern in Europe. The national societies of some countries (e.g. UK, Germany, Spain) have already introduced general guidelines for these patients (19-21). Although the widespread use of echocardiography has led to an increased diagnostic yield of truly asymptomatic patients, early surgery in such cases remains a matter of debate in Europe in light of possible perioperative mortality, morbidity and long-term complications, despite the expected benefits of preventing either sudden death, embolism or left ventricular dysfunction (22).

Intervention challenge

Catheter-based procedures to treat valve lesions were introduced with great hope by cardiologists, but did not fulfil their promise. Percutaneous aortic or pulmonary valve replacement has been successfully pioneered in humans recently (23,24). Balloon dilatation or stent insertion for bioprosthetic stenosis has been introduced, and percutaneous mitral valve repair has also been carried out. Despite these technical 'marvels', catheter-based procedures have not influenced patient yield for valve surgery, and are unlikely to do so in the immediate future.

Hybrid procedures such as salvage coronary stent-

ing followed by valve surgery and coronary bypass following salvage mitral valve balloon dilatation have been reported, but have not yet entered the mainstream clinical arena.

Saturation of facilities and services

The current unemployment and under-employment of cardiac surgeons in the USA has focused attention on their cohorts in Europe, and the resultant output in valve surgery. The situation in Europe - even for 'coronary' surgeons - is not as acute as in the USA, and consequently cardiac surgical output and valve surgery productivity has not yet shown any negative impact. This is primarily due to an increased content of 'socialized' medicine in healthcare delivery systems in many countries, fewer financial pressures, and a greater extent of support for cardiac surgical programs from national governments. However early trends are discernible. The rate of rise of valve surgery output is likely to plateau off in 'saturated' areas such as Benelux, Scandinavia, Central and West European countries, while an increased output in valve surgery is anticipated in the Mediterranean, Baltic and Middle European states.

Similarly, despite the intensive promotion of bio-prosthetic valves by their manufacturers, mechanical valves continue to dominate the market. In retrospect, traditional market indicators - namely the profit:earnings (PE) ratio and the profit:earnings:growth (PEG) ratio of the related industries during the decade have indicated the same outcome. Current capital-intensive innovations such as robotic valve surgery, minimally invasive valve surgery and bioengineered valves - each driven by their respective industries - have found niches in some West European centers but have not yet been incorporated into the general trend of clinical practice.

Resources

Conventional wisdom associates cardiac surgical output with the 'prosperity' of a region or of a country. Turina (25) noted an almost linear relationship between per capita GNP and the number of cardiothoracic surgeons in a region. The GNI-PPP is a more sensible and contemporary parameter in assessing such a correlation in a country or region. The relationship between valve surgery output (or cardiac surgical output) of a region and the GNI-PPP has been found to be non-linear and multifactorial. Increased 'prosperity' in terms of a country's GNI-PPP boosts cardiac surgery and valve surgery output only in the initial take-off and ascent phases, and any subsequent rise in prosperity is not reflected in further surgical productivity. Beyond a critical threshold, a rise in the GNI-PPP has not led to any proportional rise in valve surgery out-

put in numbers per million population (Fig. 8). In 2000, the per capita GNI-PPP in the Baltic states (7,797 \$US) was lower than that of Middle European states (10,434 \$SD) or even the Balkan states (7,890 \$US), yet valve surgery output (per 10⁶ population) in the Baltic states (137 per 10⁶) was much higher than in either Middle Europe (94 per 10⁶) or the Balkans (66 per 10⁶).

Besides prosperity and international investor dependency, the national epidemiology, priorities, healthcare delivery system and political structure were determinants of an increased quantum of care in terms of procedures per million population.

In conclusion, the findings of the present study reflect the pattern of valve surgery on a continental basis. At the end of the last millennium, valve surgery in Europe appeared to be at a cross-roads, with new technologies being spawned and the initiation and clear influence on the application of surgical procedures being noted at some centers of excellence. Despite the greater political and economic integration of Europe, the epidemiology and pattern of valve surgery continues to remain extremely diverse within the continent. Moreover, variability in resources and healthcare delivery systems in different regions will continue to contribute to this diversity. Thus, a regional/zonal rather than any 'European' standard may continue to be more relevant when assessing the valve surgery performance of any individual European country.

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Meeting discussion

DR. KARYN S. KUNZELMAN (Lewiston, Maine, USA): I don't know if your databases allowed this analysis, but with the increase in valve surgery could you tell if all surgeons were increasing numbers equally, or do those surgeons who specialize in valve surgery account for some of the increase?

DR. PROBAL GHOSH (Salzburg, Austria): The data were collected not only from these databases, but also annually from coordinators in different countries. We have not analyzed the data to see if there is a specific increase in certain centers - it was treated as a total region. At times, we have analyzed in terms of a city, which is a large number of groups, but I cannot specifically address whether the data are related to surgeons, or not.

DR. ULRICH ROSENDAHL (Lahr, Germany): I was

very surprised to see a value of 9.8% conservative mitral valve surgery in Germany. That means 9.8% reconstructive mitral valve surgery basically. I am amazed where you obtained this number, because I know that many of my colleagues perform a lot of reconstructive surgery ...

DR. GHOSH: Germany was a fairly well-documented country. There are two reports from there. One report - from Dr. Bruckenberg - does not address many of these analyses, but the second - from Dr. Kalmar, who has been examining data on behalf of the German Cardiovascular Society - publishes the analyzed data subsetwise every year. In fact, these data are to be published in *Thoracic and Cardiovascular Surgeon*. These data are from the Kalmar report.

DR. WILLEM FLAMENG (Leuven, Belgium): Dr. Ghosh, one of your conclusions was that aortic valve surgery numbers are increasing; is that correct?

DR. GHOSH: Regionwise, yes - if you take the total of Europe, yes, they are increasing. The rate of increase is much more relative to mitral surgery in England, whereas the rate of increase is much, much slower in Spain and in Italy.

DR. FLAMENG: And is there any relationship with age?

DR. GHOSH: No. There is, by and large, the median age. I do not have the validated data from each country, so I did not include it, but the median age in England has gone up by about five years over this period, according to the Valve Registry maintained by Dr. Taylor. Mean age has also increased in Italy since the Italian Society provided its data over the last five years. So, the rate of increase in the age of valve patients has increased throughout Europe, except in the Balkan region. The rate of increase is much more in the Baltic and Scandinavia, yet the rate of aortic valve surgery has increased much more in France and Germany vis-a-vis in Scandinavia or Spain.

DR. GAETANO THIENE (Padova, Italy): The recent trend of increasing the use of valve bioprostheses - I wonder whether this is a fashion, or is it related to the indication for aortic valve replacement?

DR. GHOSH: When we were analyzing the data, I started with that impression because there has been intensive promotion of bioprostheses in the literature. The annual reports of several major companies also referred to that point. But when we collected the data for the number of mechanical prostheses implanted by country, the results that emerged were startling. The only countries exceeding the 50% threshold today are England and Austria. In other countries there is a slow trend - as in Germany, Spain and Italy - but the trend is very, very slow. Bioprosthesis use is still just about 40% - the current implant data are still predominantly for mechanical valves.