

# Interventional Cardiology in Switzerland during the Year 2007

Micha T. Maeder, Stephan Windecker, Marco Roffi, Christoph A. Kaiser, Jean-Christoph Stauffer, Giovanni Pedrazzini, Hans Rickli

On behalf of the Working Group "Interventional Cardiology and Acute Coronary Syndrome"

## Summary

**Background:** Since 1987, a nationwide annual survey of percutaneous cardiac interventions is performed in Switzerland in order to assess trends with respect to type and frequency of endovascular cardiac procedures.

**Methods:** Volume and type of endovascular procedures performed during the year 2007 were collected, by means of a standardised questionnaire, from all adult invasive cardiac intervention centres in Switzerland.

**Results:** A total of 37 489 coronary angiographies (CA; 2006: 36 817; +1.8%) and 17 080 percutaneous coronary interventions (PCI; 2006: 17 061; +0.1%) were performed in 28 centres (5 university, 10 public, non-university, and 13 private hospitals). Most PCI (92%) were performed ad hoc, and 80% of them were single vessel interventions. Stents were used in 91% of all PCI (2006: 89%). Drug-eluting stents (DES) were predominantly used although at a lower rate than during the previous year (2007: 71% of all stents; 2006: 82%). Emergency PCI for ST-segment elevation myocardial infarction accounted for 22% of PCIs (2006: 20%). Whereas the numbers of valvuloplasties of the mitral (n = 40), aortic (n = 20), and pulmonary (n = 6) valves did not differ from previous years, transcatheter aortic valve implantation was introduced as a new therapeutic intervention (n = 18). The number of procedures for patent foramen ovale (PFO; n = 624; 2006: 515) and atrial septal defect closure (n = 116; 2006: 88) continued to increase.

**Conclusions:** In 2007, the increase in the number of CA and PCI continued to flatten but did not decrease in Switzerland. The use of DES remained high, although there was a decrease compared to the previous year. In contrast, procedures for percutaneous PFO and atrial septal defect closure were performed with increasing frequency. During that year, transcatheter aortic valve implantation was introduced.

**Key words:** coronary angiography; angioplasty; stents; balloon valvuloplasty; patent foramen ovale; transcatheter aortic valve implantation

## Introduction

Since 1987, a nationwide survey of interventional procedures in all Swiss cardiology centres is performed annually [1, 2] in order to assess trends with respect to type and frequency of endovascular cardiac procedures. In particular, we were interested to identify whether studies on controversial topics, including percutaneous coronary intervention (PCI) in patients with stable coronary artery disease and the use of drug-eluting stents (DES) published in 2006/2007 may have influenced the volume of procedures performed in 2007 compared to previous years. Thus, the aim of the present report was to provide cardiologists, primary care physicians, as well as the public health community, with the most recent data on interventional cardiology practice in the country.

## Methods

Based on a standardised questionnaire [2], all cardiology centres performing interventional procedures on adult patients were asked to report on procedures performed during the year 2007. The requested items included data about infrastructure, operators, availability of cardiac surgery, number of coronary angiographies (CA) and PCI, detailed information about the circumstances of PCI (*ad hoc* interventions, single-vessel vs multi-vessel PCI), types of stents [bare-metal stents (BMS) or DES], other revascularisation techniques (e.g., rotablator), adjunctive techniques such as use of distal protection devices, use of mechanical circulatory support, glycoprotein IIb/IIIa inhibitors, and complications. In addition, centres were asked to report interventions for structural heart disease such as balloon valvuloplasties or closure of

No conflicts of interest to declare.

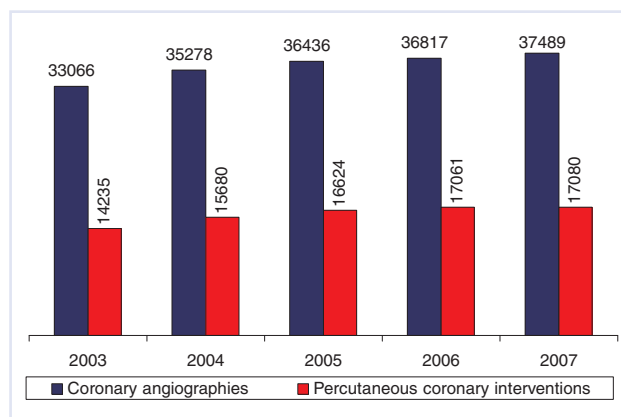
Micha T. Maeder was supported by the Swiss National Science Foundation (Grant PBZH-121007).

Correspondence:

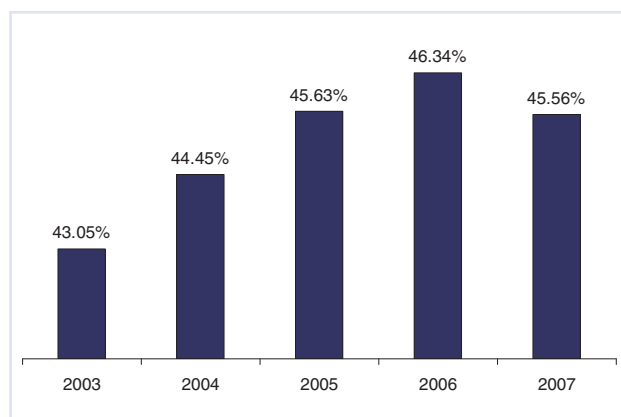
Micha T. Maeder, MD  
Fachbereich Kardiologie  
Kantonsspital St. Gallen  
Rorschacherstrasse 95  
CH-9007 St. Gallen  
micha.maeder@bluewin.ch

**Figure 1**

Evolution of coronary angiographies and percutaneous coronary interventions from 2003 to 2007.

**Figure 2**

Evolution of the percutaneous coronary intervention (PCI) to coronary angiography (CA) ratio from 2003 to 2007. The bars represent the PCI/CA ratio.



intracardiac shunts. For the first time, we also collected information about the number of transcatheter aortic valve implantation (TAVI) procedures performed in 2007, although this was not an item on the initial questionnaire. The questionnaires were returned by all centres contributing data in the last years, although for some centres, information was not available for all items. One centre with interventional cardiology activity has not contributed data in previous years, and refused to participate in the current report (Lindenhofspital, Bern).

The following definitions were applied:

**CA:** diagnostic cardiac catheterisation for visualisation of the coronary arteries, independently whether or not an intervention is performed in the same session. The number of cases is recorded.

**PCI:** coronary angioplasty with or without stent placement. If PCI is performed directly following the diagnostic procedure during the same session, it is referred to as *ad hoc* PCI. The number of cases, but not the number of vessels dilated, is recorded.

## Results

### Structure of Swiss centres

In 2007, there were 28 active centres (5 university, 10 public, non-university, 13 private hospitals), all of which performed both diagnostic procedures and PCI. At the beginning of 2007, the Cantonal Hospital in Fribourg opened a new cardiac catheterisation facility. As in the previous two years, the University Hospital Zürich (UniversitätsSpital Zürich; USZ), the Kantons-spital Winterthur (KSW) and the Spital Thurgau AG (Frauenfeld) were considered as a single centre, as there is an established collaboration between these hospitals. Among the 28 centres, 12 institutions had one catheterisation laboratory, 12 centres had two, three centres had three, and one centre (USZ/KSW/Frauenfeld) performed procedures in five locally separated catheterisation laboratories. A total of 34 (2006: 64) operators performed exclusively diagnostic studies, whereas 138 (2006: 129) cardiologists performed both CA and PCI. In 18 centres, cardiac surgery was available on site.

### Coronary interventions

During the year 2007, 37 489 CA (2006: 36 817; +1.8%) and 17 080 PCI (2006: 17 061; +0.1%) were performed. Over the last five years, the increase in the number of both CA and PCI has flattened, and the number of PCI seems to have reached a plateau (fig. 1). The PCI/CA ratio remained more or less unchanged as compared to the previous year, whereas this ratio was continuously increasing from 2003 to 2006 (fig. 2). In 92% of cases (2006: 93%; data not available from five centres), PCI was performed *ad hoc*. The majority of PCI procedures constituted of single-vessel interventions (80%; data not available from three centres; 2006: 78%).

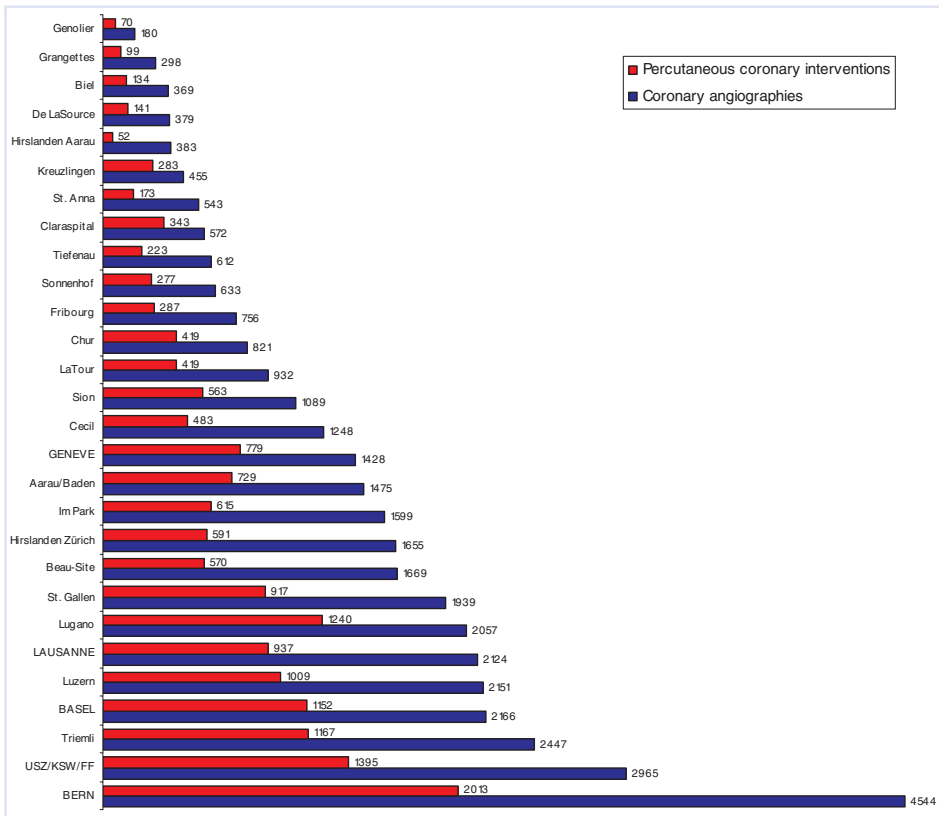
Figure 3 shows the distribution of diagnostic and interventional procedures among the different centres. The calculated average number of CA and PCI performed per operator were 218 (2006: 191) and 124 (2006: 132) respectively. The average number of procedures per operator differed widely among centres, as shown in figure 4. The average number of PCI per operator was 157 (2006: 176) in university hospitals, 154 (2006: 165) in public, non-university hospitals, and 76 (2006: 78) in private hospitals.

### Coronary stents

The rate of stent utilisation was 91% (data not available from one centre; 2006: 89%). The evolution of the utilisation of stents from 1992 to 2007 is shown in figure 5. In 42% of PCI procedures (2006: 42%), two or more stents were implanted (data not available from four centres). For 71% of all stents (data not available from three centres), DES constituted the most frequently applied stent type. However, for the first time since the introduction of DES in Switzerland, there was

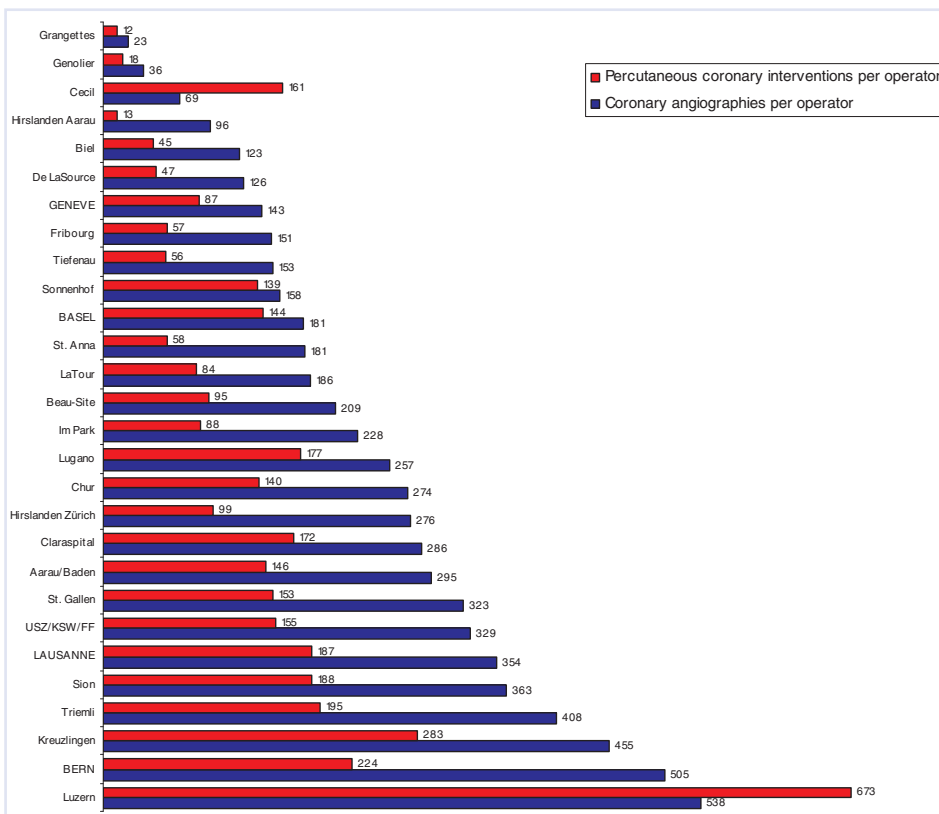
**Figure 3**

Coronary angiographies and percutaneous coronary interventions in different centres. The centres are grouped according to their annual volume. USZ = UniversitätsSpital Zürich; KSW = Kantonsspital Winterthur; FF = Spital AG Thurgau (Frauenfeld).



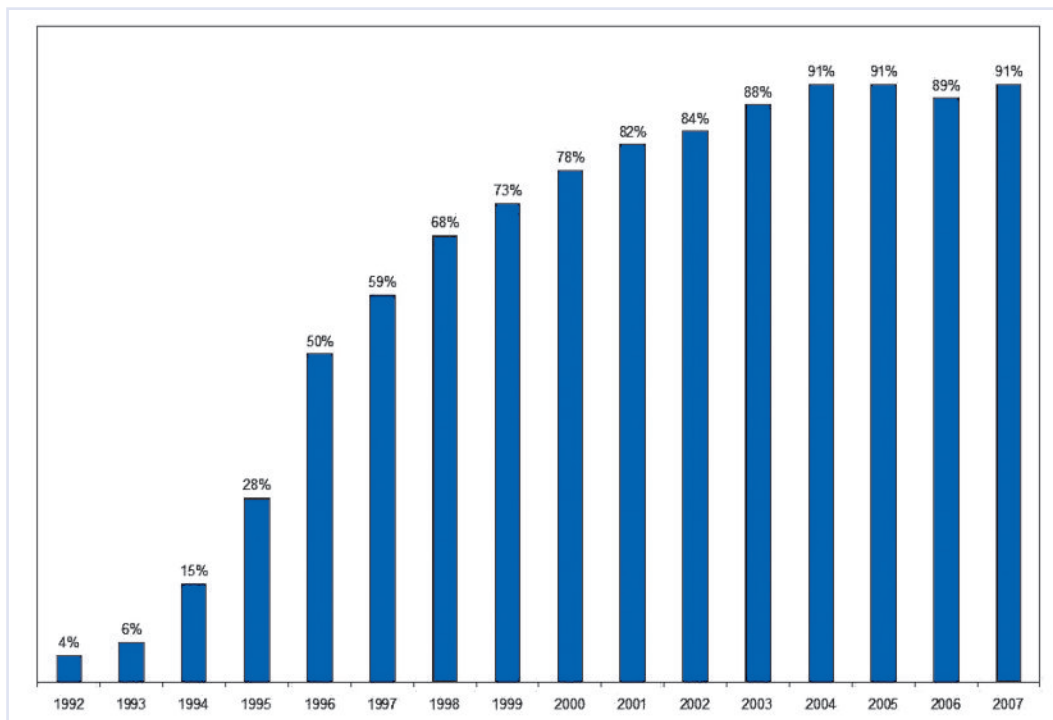
**Figure 4**

Coronary angiographies and percutaneous coronary interventions per operator in different centres (grouped according to the annual average volume per operator). USZ = UniversitätsSpital Zürich; KSW = Kantonsspital Winterthur; FF = Spital AG Thurgau (Frauenfeld).

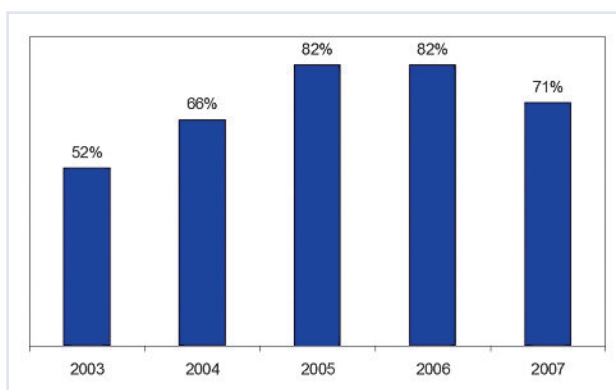


**Figure 5**

Evolution of the use of stents between 1992 and 2006. The bars represent the stent utilisation rates (percutaneous coronary interventions with stent placement / all percutaneous coronary interventions).

**Figure 6**

Evolution of the use of drug-eluting stents between 2003 and 2006. The bars represent the drug-eluting stent utilisation rates (interventions with drug-eluting stent placement / all interventions with stent implantation).



a decrease in the utilisation of DES from 82% in 2006 to 71% (fig. 6). The proportion of DES varied considerably among different centres ranging from 44 to 100%.

### PCI for acute myocardial infarction

Emergency interventions in patients presenting with ST segment myocardial infarction (STEMI; primary PCI or rescue PCI after failed thrombolysis) accounted for 22% of PCI procedures (data not available from six centres; 2006: 20%). The proportion of PCI for STEMI among all interventions was higher in university hospitals (26%) and public, non-university hospitals (23%) as compared to private hospitals (12%). Glycoprotein

Iib/IIIa inhibitors were used in 24% of all PCI procedures (data not available for four centres; 2006: 19%). PCI for cardiogenic shock accounted for 1.9% (data not available from six centres). During 2007, 435 (2006: 437) intra-aortic balloon pumps and 66 (2006: 56) percutaneous left ventricular assist devices were used.

### Adjunctive techniques and special interventions

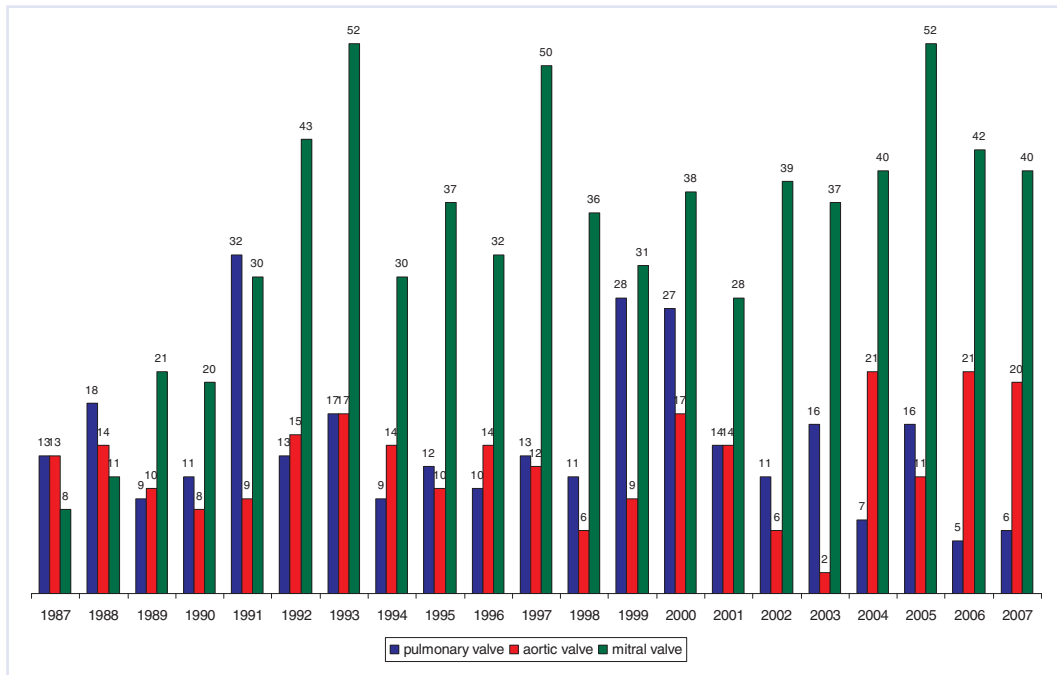
Distal protection devices were used in 1.3% of PCI cases (2006: 3.3%), an intracoronary pressure wire was employed in 3.8% (2006: 2.6%) of cases, and intravascular ultrasound was performed in 5.0% of PCI (2006: 3.9%). Revascularisation techniques other than balloon angioplasty included rotablation (69 cases; 2006: 62) and atherectomy (197 cases; 2006: 0). Intracoronary brachytherapy was no longer used. Alcohol ablation of septal hypertrophy was performed in 31 (2006: 44) patients.

### Complications after PCI

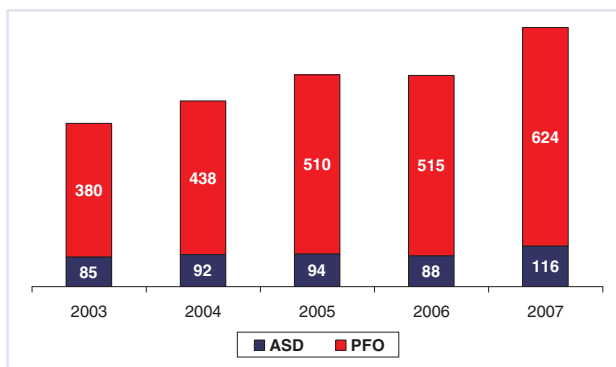
Myocardial infarction after PCI was reported in 1.0% of procedures (2006: 1.5%), emergency coronary artery bypass grafting was required in 0.2% of cases (2006: 0.2%), and mortality following PCI was reported to be 0.5% (2006: 0.6%). However, data on complications were not provided by five centres, and the broad range of myocardial infarction (0.5–2.9%) and mortality (0–2.6%) rates suggests that there were significant differences in the definitions of myocardial infarction (which

**Figure 7**

Balloon valvuloplasties from 1987 to 2007. The figure does not include percutaneous aortic valve implantations performed in 2007 (n = 18).

**Figure 8**

Interventions for closure of structural defects from 2003 to 2007. ASD = atrial septal defect; PFO = patent foramen ovale.



was not given in the questionnaire) and in the scrutiny of clinical follow-up.

### Non-coronary interventions

The number of balloon valvuloplasties (fig. 7) did not differ markedly from previous years. For the first time in Switzerland, TAVI was performed in 2007 (n = 18; all procedures performed at the Inselspital Bern). There was an increase in the number of procedures for PFO and atrial septal defect (ASD) closure (fig. 8). Other interventions for repair of structural defects included ventricular septal defect closure (n = 10) and patent ductus arteriosus closure (n = 8). In addition, 14 angioplasties/stenting for a coarctatio of the aorta were performed.

### Non-cardiac interventions

Peripheral angioplasties were carried out by radiologists and angiologists in most hospitals. However, cardiologists reported 245 (2006: 237) iliac or lower extremity interventions (38% with stent placement), 83 (2006: 158) carotid artery angioplasties (100% with stent implantation), and 139 (2006: 201) renal artery interventions (91% with stent placement). Percutaneous treatment of thoracic or abdominal aortic aneurysms was occasionally reported but was not an item included in the questionnaire.

### Discussion

The present survey provides important insights into temporal changes of invasive cardiac procedures in Switzerland. We observed the following main findings: (1.) a plateau in the number of PCI, (2.) a small decrease in the utilisation of DES, although they remained the most frequently used type of stent, (3.) an increase in the number of procedures for PFO and ASD closure, and (4.) the introduction of TAVI.

The number of CA and PCI has flattened, and the number of PCI seems to have reached a plateau over the last years but did not decrease. It appears that the impact of studies comparing optimal medical treatment with PCI suggesting similar efficacy [3] had only a minor impact on daily practice. Moreover, revascularisation procedures, including PCI and coronary artery bypass grafting, remain important therapeutic measures to alleviate ischaemia and have been repeatedly

shown to improve prognosis in patients with large areas of ischaemic myocardium. However, it must be pointed out that given the lack of detailed information on indications for PCI in our survey, this and the following reflections on the impact of comparatively recent data (published in 2006 or 2007 to have impact on activities reported in this survey) remain speculative, and caution is warranted not to over-interpret this data from a catheterisation lab-based questionnaire. Between the end of the study period and the publication of this report, “appropriateness criteria” for PCI [4], taking into account the COURAGE [3] and other recent trials, have been published. Only the analysis of the 2009 data will possibly show the impact of these recommendations on the practice of PCI in stable patients in Switzerland.

PCI for STEMI remains broadly applied. Larger centres have established a 24 hour service for primary PCI. According to an analysis of the AMIS Plus registry, including 12 026 patients admitted to 68 hospital in Switzerland between 2000 and the end of 2007 [5], the proportion of STEMI patients undergoing primary PCI has increased from 43% to 85% from 2000 to 2007, and the thrombolysis rate has decreased from 40% to 2%. This change in practice was associated with a reduction in in-hospital mortality from 7.6% to 6%, re-infarction from 3.7% to 0.9%, and stroke from 1.8% to 0.8% [5]. Another recently published analysis from the AMIS Plus registry [6] revealed a reduction in in-hospital mortality and a decrease in the incidence of cardiogenic shock during hospital stay, following acute coronary syndrome in Switzerland between 1997 and 2006. PCI was an independent predictor for both a lower all cause mortality in the overall population and a lower incidence of cardiogenic shock within the group of patients with acute coronary syndrome but without shock on admission, supporting the role of PCI in the acute setting.

In contrast to the evolution within the previous three years, the DES utilisation rate has decreased for the first time, and a similar trend was observed in Austria during the year 2007 [7]. The phenomenon of very late stent thrombosis after DES implantation [8] may have contributed to the more selective use of DES. However, no study has demonstrated an adverse effect of DES on survival [9]. Thus, given the benefit of DES in terms of reduced target lesion revascularisation [10, 11] and the similar outcome in terms of ischaemic adverse events, the proportion of DES is likely to increase again.

The number of balloon valvuloplasties did not change as compared to previous years. However, TAVI was introduced in Switzerland with the first procedures performed at the Inselspital in Bern [12]. Given the number of eligible patients for TAVI, additional centres have implemented this procedure, and the data will be updated regularly in future surveys.

Interestingly, the number of procedures for PFO closure showed a marked increase, after there had been no increase between 2005 and 2006. Indications for PFO closure are still under debate, and there is no consensus regarding optimal management of patients with PFO and stroke. It is widely accepted that young patients with recurrence of stroke, despite antithrombotic therapy, should undergo PFO closure [13]. In daily practice, PFO closure is typically performed more liberally in patients with cryptogenic stroke. It has been suggested that all high risk patients with cryptogenic stroke may benefit from PFO closure, in terms of prevention of recurrence [14]. The association between PFO with and without atrial septal aneurysm and stroke was initially accepted only for younger patients (<55 years). However, recent data from a large observational study suggest that such a relationship may also apply for older patients [15], which might give rise to speculations about expanding indications for PFO closure. However, this study was published at the end of 2007 and thus, is unlikely to have significantly contributed to the practice in 2007. The results of ongoing prospective randomised trials comparing PFO closure with medical therapy (summarised in [16]) are awaited and will hopefully more clearly define the role of PFO closure in patients with stroke. However, this trial recruits slowly, and referral bias is a concern [14, 16]. It also has to be considered that the increase in PFO closure procedures may, in part, have been due to indications other than secondary prevention after stroke, including PFO closure in divers or patients with migraine.

### Limitations of the study

Data reporting was incomplete with respect to several items, and some centres were not prepared to present all of the data of interest. Accordingly, results must be interpreted cautiously. In addition, periprocedural complications are likely to be underreported due to detection bias. A catheterisation laboratory-based analysis is unlikely to be complete, and we can assume that only complications occurring immediately at the time of catheterisation have been included.

### Conclusions

The number of CA and PCI has flattened over recent years. The use of DES remained high, although there was a decrease compared to the previous year. Procedures for percutaneous PFO and ASD closure are performed with increasing frequency. Transcatheter aortic valve implantation was performed for the first time in Switzerland in 2007.

## Appendix / local coordinators

Aarau Kantonsspital:	A. Vuillomenet
Aarau Hirslanden Klinik:	C. Neuenschwander
Basel Universitätsspital:	C. Kaiser
Basel Claraspital:	B. Hornig
Bern Universitätsspital:	S. Windecker
Bern Klinik Beau-Site:	C. Noti
Bern Klinik Sonnenhof:	A. Garachemani
Bern Tiefenauspital:	M. Brack
Biel Spitalzentrum:	C. Röthlisberger
Chur Kantonsspital:	P. Müller
Fribourg Kantonsspital:	J.C. Stauffer
Genève Clinique des Grangettes:	P. Chatelain
Genève Hôpitaux Universitaires:	P.A. Dorsaz
Genolier Clinique:	V. Verin
Kreuzlingen Herzzentrum Bodensee:	M. Pieper
Lausanne Clinique Cecil:	J.C. Goy
Lausanne Clinique de la Source:	G. Rouvinez
Lausanne Centre Hospitalier Universitaire Vaudois:	C. Roguelov
Lugano Cardiocentro:	G. Pedrazzini
Luzern Kantonsspital:	P. Erne
Luzern Klinik St. Anna:	M. Waser
Meyrin Hôpital La Tour:	P. Urban
Sion Hôpital Régional:	G. Girod
St. Gallen Kantonsspital:	D. Weilenmann
Zürich Klinik Hirslanden:	E. Schuiki
Zürich Klinik im Park:	F.W. Amann
Zürich Triemli Stadtpital:	F. Eberli
Zürich Universitätsspital/ Winterthur Kantonsspital/ Thurgau Spital AG (Frauenfeld):	W. Maier

## References

- Meier B. Oertliche Entwicklung der Koronarangioplastie. *Schweiz Med Wochenschr.* 1989;119:1033–9.
- Maeder MT, Stauffer JC, Windecker S, Pedrazzini G, Kaiser CA, Roffi M, et al. Interventional cardiology in Switzerland during the year 2006. *Kardiovaskuläre Medizin.* 2008;11:187–95.
- Boden WE, O'Rourke RA, Teo KK, Hartigan PM, Maron DJ, Kostuk WJ, et al.; COURAGE Trial Research Group. Optimal medical therapy with or without PCI for stable coronary disease. *N Engl J Med.* 2007;356:1503–16.
- Patel MR, Dehmer GJ, Hirshfeld JW, Smith PK, Spertus JA. ACCF/SCAI/STS/AATS/AHA/ASNC 2009 appropriateness criteria for coronary revascularization: a report of the American College of Cardiology Foundation Appropriateness Criteria Task Force, Society for Cardiovascular Angiography and Interventions, Society of Thoracic Surgeons, American Association for Thoracic Surgery, American Heart Association, and the American Society of Nuclear Cardiology. *Circulation.* 2009;119:1330–52.
- Stolt Steiger V, Goy JJ, Stauffer JC, Radovanovic D, Duvoisin N, Urban P, Bertel O, Erne P for the AMIS Plus Investigators. Significant decrease in in-hospital mortality and major cardiac events in Swiss STEMI patients between 2000 and December 2007. Results from the AMIS registry. *Swiss Med Wkly.* 2009;139:453–7.
- Jeger RV, Radovanovic D, Hunziker PR, Pfisterer ME, Stauffer JC, Erne P, et al.; AMIS Plus Registry Investigators. Ten-year trends in the incidence and treatment of cardiogenic shock. *Ann Intern Med.* 2008;149:618–26.
- Mühlberger V, Pachinger O. Herzkathetereingriffe in Oesterreich im Jahr 2007 (mit Audit 2004 bis 2008). *J Kardiol.* 2009;16:86–103.
- Pfisterer M, Brunner-LaRocca HP, Buser PT, Rickenbacher P, Hunziker P, Mueller C, et al. for the BASKET investigators. Late thrombotic events after clopidogrel discontinuation may limit the benefit of drug-eluting stents: an observational study of drug-eluting vs. bare-metal stents. *J Am Coll Cardiol.* 2006;48:2584–91.
- Daemen J, Simoons ML, Wijns W, Bagust A, Bos G, Bowen JM, et al. Meeting report ESC forum on drug eluting stents European Heart House, Nice, 27-28 September 2007. *Eur Heart J.* 2009;30:152–61.
- Morice MC, Serruys PW, Sousa JE, Fajadet J, Ban Hayashi E, Perin M, et al. A randomised comparison of a sirolimus-eluting stent with a standard stent for coronary revascularization. *N Engl J Med.* 2002;346:1773–80.
- Stone GW, Ellis SG, Cox DA, Hermiller J, O'Shaughnessy C, Mann JT, et al. A polymer-based, paclitaxel-eluting stent in patients with coronary artery disease. *N Engl J Med.* 2004;350:221–31.
- Wenaweser P, Windecker S, Gerckens U, Grube E, Meier B. Der perkutane Aortenklappenersatz. *Kardiovaskuläre Medizin.* 2008;11:131–9.
- Kizer JR, Devereux RB. Patent foramen ovale in young adults with unexplained stroke. *N Engl J Med.* 2005;353:2361–72.
- Windecker S, Meier B. Patent foramen ovale and cryptogenic stroke: to close or not to close? Closure: What else! *Circulation.* 2008;118:1989–98.
- Handke M, Harloff A, Olschewski M, Hetzel A, Geibel A. Patent foramen ovale and cryptogenic stroke in older patients. *N Engl J Med.* 2007;357:2262–8.
- O'Gara PT, Messe SR, Tuzcu EM, Catha G, Ring JC. Percutaneous device closure of patent foramen ovale for secondary stroke prevention. A call for completion of randomized clinical trials. A science advisory from the American Heart Association/American Stroke Association and American College of Cardiology Foundation. *Circulation.* 2009;119:2743–7.