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Austrian National CathLab Registry (ANCALAR): cardiac catheterization, coronary angiography (CA), and percutaneous coronary intervention (PCI) in Austria during the year 2011 (Registry Data with Audit including 2012)

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Summary Concerning international comparison for the year 2011, Austria is situated under the top nations with

- 6,383 diagnostic coronary angiographies (CA),
- 2,407 percutaneous coronary interventions (PCI), and
- 47 transarterial aortic valve implantations (TAVI)

per 1 million inhabitants in Europe. Although the number of TAVI increases rapidly since its first introduction in 2007 (47 TAVI per 1 million inhabitants in 2011, not including surgical cases from the transapical route), the data for CA and PCI remained constant during the past years.

The rates of stent (91 %) and drug-eluting stent implantations (78 % of stents) also remained constant on a high level. Little fluctuation is also reflected in the complication data (including mortality evaluation). An increased morality is well known, especially in patients with the so-called ST-segment elevation myocardial infarction and consecutive shock (19–35 % in the past years).

The application of certain special devices increased (clot catcher) or decreased (glycoprotein IIb/IIIa receptor antagonist) in 2011 or were finally unused (Laser).

Interestingly, not only in Austria, it was observed several times that scientific knowledge, recommended as Class I Indications in the guidelines, takes several years to establish itself nationwide.

Our independent, purely academic activity is located in the area of health services research, and has also the option to generate benchmarks for individual centers. Participation in our surveys is voluntary. Since 1992, every year, without interruption (no missing center!), 90–100 parameters are applicable. The questionnaire will be optimized and adapted to current conditions. This is done in cooperation with the participating centers. To provide comparability, we make only minimal and absolutely most necessary modifications.

The data are collected and summarized at the end of the year by each center itself. During the year, the centers are visited to perform audits and to keep personal contact to them.

The data for 2011 were presented in Linz (November 23, 2012) at the autumn meeting of the working group "Interventional Cardiology of the Austrian Society of Cardiology" (ÖKG), as a basis for discussion. The presentation can be viewed by using private access code to the ÖKG video presentation page (http://oekg.medroom.at/); the publication will also be placed under the website http://iik.i-med.ac.at.

Keywords Austrian National CathLab Registry (ANCALAR) · PCI · CA · Diagnostic coronary angiography · Percutaneous coronary intervention · Heart catheterization · Cardiology · Statistics · Austria

im Auftrag der Datenverantwortlichen aller österreichischen Herzkatheterzentren (siehe Anhang—Austrian Society of Cardiology (ÖKG), c/o Division of Cardiology, Department of Medicine II, Währinger Gürtel 18–20, 1090 Vienna, Austria)

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Austrian National CathLab Registry (ANCALAR): Herzkathetereingriffe in Österreich im Jahr 2011 (mit Audit bis 2012)

Zusammenfassung Im internationalen Vergleich für das Jahr 2011 liegt Österreich (A) mit

- 6.383 diagnostischen Koronarangiographien (CA)
- 2.407 perkutanen koronaren Interventionen (PCI)
- 47 transarteriellen Aortenklappen Implantationen (TAVI)

bezogen auf 1 Mio. Einwohner im Europäischen Spitzenfeld.

Während die Anzahl der TAVI seit der Ersteinführung im Jahr 2007 rapide zunimmt (noch nicht inkludiert sind dabei die zusätzlich rein chirurgischen transapikalen Implantationen), blieben die Daten für die CA und die PCI in den letzten Jahren konstant.

Die Raten der Stent- (91 %) und Drug Eluting Stent (DES)-Implantationen (78 % der Stents), blieben ebenfalls konstant. Wenig Fluktuation zeigt sich auch bei den Komplikationsdaten (inklusive erhobener Mortalität). Eine erhöhte Mortalität ist vor allem bei Patienten mit sogenannten ST-Hebungsinfarkten (STEMI) und konsekutivem Schock (19–35 % in den letzten Jahren) festzustellen.

Gewisse Nischenprudukte nahmen 2011 in der Anwendung zu (Gerinnsel-Fänger-Entferner) oder ab (Glykoprotein IIb/IIIa Rezeptorantagonisten) oder wurden endgültig nicht mehr (Laser) verwendet.

Interessanterweise konnte mehrfach beobachtet werden, dass wissenschaftliche Erkenntnisse, die ihrerseits als Klasse I Indikationen in den Richtlinien empfohlen werden, mehrere Jahre benötigen, um sich flächendeckend zu etablieren.

Unsere unabhängige, rein akademische Aktivität ist im Bereich der Versorgungsforschung anzusiedeln und verfügt zusätzlich über die Option, Benchmarks für einzelne Zentren zu generieren. Die Teilnahme an unseren Erhebungen ist freiwillig. Seit 1992 werden jährlich ohne Unterbrechung, flächendeckend (kein Zentrum fehlt!) zwischen 90 und 100 Parametern erhoben. Der Fragenkatalog wird laufend optimiert und den aktuellen Gegebenheiten angepasst. Dies geschieht in Kooperation mit den teilnehmenden Zentren. Um die Vergleichbarkeit zu gewähren erfolgen allerdings nur minimalste und absolut notwendigste Modifikationen.

Die Daten werden gesammelt und summiert am Jahresende von den einzelnen Zentren übermittelt. Unterjährig erfolgen Audits vor Ort um auch den persönlichen Kontakt zu pflegen.

Die Daten für 2011 dienten in Linz (23.11.2012) im Rahmen der Herbsttagung der Arbeitsgruppe „Interventionelle Kardiologie" der "Österreichischen Kardiologischen Gesellschaft" (ÖKG) unter anderem als Diskussionsgrundlage. Die Präsentation ist mittels eigenem Zugangscode auf der ÖKG-Videovortragsseite (http://oekg.medroom.at/) einsehbar, die Publikation erfolgte bisher im Journal für Kardiologie sowie unter http://iik.i-med.ac.at.

Schlüsselwörter Austrian National CathLab Registry (ANCALAR) · PCI · CA · Diagnostische Koronarangiographien, perkutanen Koronaren Interventionen · Herzkathetereingriffe · Kardiologie · Statistik · Österreich

Introduction

The 20th annual update, including yearly publications of Austrian surveys since 1992, focuses on percutaneous coronary interventions (PCI), diagnostic coronary angiographies (CA), and other cardiac catheter interventions in Austria in 2011. International comparisons [1–8] have been generated as based on results of population censuses in this country (8.43 million inhabitants; cutoff date: October 31, 2011), data accumulated from 1992 to 2011 [1–4], and results obtained from other countries—in particular, Switzerland (7.95 million inhabitants; December 31, 2011) and Germany (81.9 million inhabitants; June 30, 2012).

As of 2011 and 2012, in Germany and Switzerland, respectively, the associations of cardiology have carried out the relevant surveys and assessments instead of hitherto established personalities [5–8]. In Germany, the two involved associations were to strike an agreement, thus resulting in modifications of publication policies [7, 8]. In Switzerland, a transition was initiated to web-based publications, and publishing activities were subsequently conducted by rotation among the respective working group presidents [5, 6].

In 2012, the Swiss Federal Office of Public Health posted the first nationwide comparison between hospitals on the Internet, covering the period from 2008 to 2010 (www.bag.admin.ch/qiss).

The European Society of Cardiology (ESC; www.escardio.org) currently manages the Austrian data presented in this overview, termed "Austrian National CathLab Registry" (ANCALAR). ANCALAR is fully independent from governmental, industrial, economic, and actuarial influences ("no conflict of interests including V. Mühlberger*, C. Kobel**, L. Kaltenbach**, O. Pachinger"; all studies have been performed in accordance with ethical standards).

In practice, the Austrian centers apply the present data both as benchmarks and in the framework of quality management procedures.

Methods

By tradition, the survey is nationwide and comprehensive (Table 1); methods have been described previously [1–4]. The basis of the survey is the data set of the Working Group for Interventional Cardiology and Coronary Pathophysiology (WG 10), and/or the ESC Coronary Circulation Working Group, and (since August 2006) the European Association of Percutaneous Cardiovascular Interventions), including integrated instructions for and examples of data collection (www.kardiologie.insel.ch/2164.html). Furthermore, an Austria-specific ques-

Table 1 Cardiac catheter structure in Austria, 2008–2011

Number (*n*)	2008	2009	2010	2011
Centers	37	38	37	36
Audit requested	*29*	26	26	*26*
Audit carried out	4	2	1	2
Tables	49	51	50	49
Internet exposure	27	29	25	25
Database	35	37	35	31
Back up on site	9	9	9	9
Back up within 90 min	37	37	37	36
On-call duty with others	14	15	14	10
On-call duty alone around the clock	13	13	14	15
Team present non-stop	2	1	3	4
Compliance with radiation protection	ns	31	36	35
CA physicians	277	*283*	*267*	*243*
PCI physicians	*220*	*264*	*214*	214

Extended original questionnaire of the European Society of Cardiology, with substantial differences italicized. The number of active physicians may be biased, as multiple answers were possible
CA coronary angiography, *PCI* percutaneous coronary intervention, *ns* not sampled

tionnaire has been applied (http://iik.i-med.ac.at). The directives of the Cardiology Audit and Registration Data Standards [9] are in force.

The deadline for feedback concerning the year 2011 was October 3, 2012. All centers (see Appendix) had transferred their data by this time (as data from one center were still incomplete, they were extrapolated and then completed). The data were presented on the occasion of the annual autumn meeting of the Interventional Cardiology Working Group, Austrian Society of Cardiology (Österreichische Kardiologische Gesellschaft, ÖKG), in Linz on November 23–24, 2011. The manuscript was made available to the centers for correction.

Statistics, structure, and audit (Table 1)

The Department of Medical Statistics, Computer Science and Health Economics, Medical University of Innsbruck, has had a leading and co-responsible role within the entire process, ranging from questionnaire design to communicating the results on the Internet.

Although a new private laboratory was established in Klagenfurt, Maria Hilf, in 2012, the centers in Ried, Braunau, and Hochegg were closed in 2010 and 2011. Thus, 36 centers were active in 2011, all of which performed both CA and PCI that year (Table 1).

From 2004 to 2012, a total of 38 monitoring visits took place in 35 of the present 36 Austrian laboratories with the objective to ensure high-level data quality. In 2012, the centers in Wels and the ITC Cardiac Catheter Laboratory, "Confraternität" Private Hospital in Vienna, were monitored. In addition, communication was constantly maintained, and the centers were contacted by telephone and

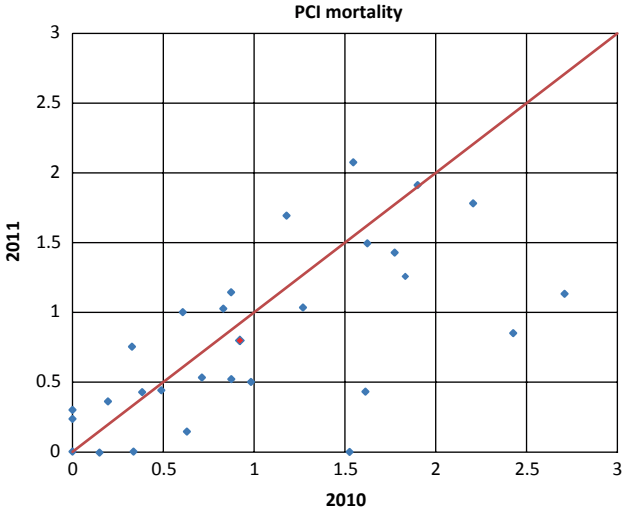

Fig. 1 Comparison of total mortality rates percutaneous coronary interventions (PCI) (with/without shock) in 2010 (*x-axis*) and 2011 (*y-axis*). The *diagonal* symbolizes constant mortality rates; the *red* symbol symbolizes the Austrian average. Centers beneath the diagonal have "improved" and centers above have "worsened" in comparison between 2010 and 2011. Centers above average in 2010 (i.e., on the right side of the *red* symbol), in particular, have apparently more strongly "improved." It should be noted, however, that a single reported death may have a great impact on low-volume centers

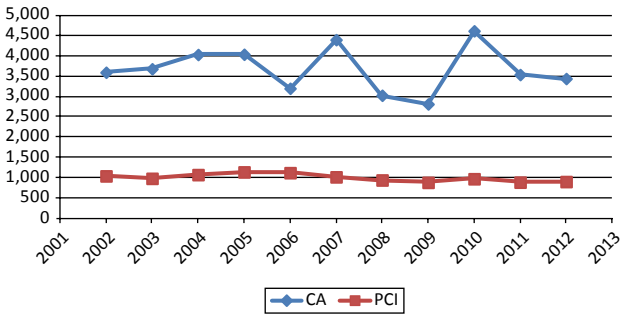

Fig. 2 With regard to "intention to audit a center," the values are shown for an individual parameter (e.g., the number of percutaneous coronary interventions and angiographies per year). An on-site review was carried out to determine striking variance and discrepancies. In this respect, the definition of angiographies was sharpened in 2011

e-mail throughout the year, especially on returning the completed questionnaires. The catheter laboratory at the Medical University of Graz was monitored in Mach 2013.

In terms of "benchmarking over the centers and years," the data (Fig. 1: total mortality) of each center in Austria were compared with the mean value over the years (e.g., 2010 and 2011).

With respect to the "intention to audit a center," the values are shown for individual parameters (Fig. 2: number of PCI and angiographies per year). An on-site review of striking variation and discrepancies was carried out. In this connection, the definition of angiographies was sharpened in 2011.

Table 2 Percutaneous coronary interventions (PCI) in Austria, 2008–2011

	Share in	2008	2009	2010	2011	*p*-value	Blank
		Percentage					
Total PCI	KAG	38.61	38.17	36.81	37.72	<0.001	0
PCI acute and/or in infarction	PCI	33.94	34.20	31.86	34.23	<0.001	0
—PCI in STEMI	PCI infarction	58.76	56.07	56.77	52.27	<0.001	5
Single-session multiple-vessel PCI	PCI	15.97	14.63	16.22	13.80	<0.001	3
Ad hoc (=single phase)	PCI	81.46	83.65	84.88	81.42	<0.001	2
Arm puncture	PCI	7.66	13.26	17.32	18.16	<0.001	1
Puncture closure devices	PCI	71.98	71.20	74.83	70.84	<0.001	5
Subsequent myocardial infarction	PCI	1.22	1.19	0.95	0.68	<0.001	5
Iatrogenic main stem dissection	PCI	0.08	0.06	0.08	0.10	n. s.	6
Emergency surgery	PCI	0.08	0.06	0.13	0.08	n. s.	4
PCI mortality	PCI	1.04	1.00	0.92	0.80	n. s.	0
Stents	PCI	87.88	89.42	91.46	90.80	<0.001	0
Drug-eluting stents	Stents	66.86	68.88	74.60	76.88	<0.001	0
Main stem stents	Stents	2.13	2.04	2.28	2.15	n. s.	1
Multiple stents	Stents	32.66	35.32	34.31	30.33	<0.001	5
PCI for in-stent restenosis	PCI	7.39	5.37	4.87	5.23	<0.001	5
—PCI for chronic hyperplasia	PCI restenosis	85.63	86.96	86.44	88.06	n. s.	16
—PCI for stent thrombosis	PCI restenosis	14.37	13.04	13.56	11.94	n. s.	16
Rotablator	PCI	1.52	1.58	1.39	1.75	<0.05	1
Clot catcher/remover	PCI	5.50	7.25	8.17	9.59	<0.001	2
Intracoronary pressure measurement	PCI	7.21	7.78	8.62	9.92	<0.001	1
IVUS (=diagnostic ultrasound)	PCI	5.57	5.23	4.74	4.48	<0.001	0
Intra-aortic balloon pump in PCI	PCI	0.69	0.89	0.95	0.77	<0.05	3
Other new devices	PCI	0.90	0.93	0.45	0.42	<0.001	5
Glycoprotein IIb/IIIa receptor AG	PCI	17.17	15.10	11.82	11.83	<0.001	4
Thrombin inhibitor	PCI	4.10	3.27	3.99	5.30	<0.001	6
"Optical coherence tomography"	PCI	0.65	0.78	1.43	1.49	<0.001	2

Absolute numbers of parameters, corrected for missing feedback, Including corrected percentages. Centers that gave no feedback on one single parameter in at least one of the years in the 2008–2011 interval were not considered for evaluation of that parameter. This changes both the quantity of that parameter (e.g., number of arm punctures) and the number in the reference category (e.g., PCI). The right column indicates corresponding information for the given parameter ("blank": *n*=number of non-considered centers). *P*-values indicate whether significant change occurred over the total interval. If not indicated otherwise, relationships are given in percentage to PCI. The centers in Ried and Grossgmain were not considered, as they are no longer active and thus do not appear as blank
STEMI ST-segment elevation myocardial infarction, *IVUS* intravascular ultrasound

To warrant international comparability with other registries, the traditional method of analysis was applied according to guidelines, i.e., a summation with corresponding percentages, also in the case of missing individual data (e.g., Fig. 7). In the case of incomplete ("blank") feedback reported by a center, a separate analysis of centers with complete feedback (without blanks) over the 2008–2011 interval was done additionally (Table 2). Centers giving no feedback on one single parameter in at least one of the years in that interval were not considered for evaluation of that parameter. In such numerical examples, however, comparisons with data that mostly undergo pooled analysis internationally may be misleading. Therefore, both methods of analysis continue to be published (e.g., Tables 3, 4, 5, 6, 7, and 8). The statistical significance of the values shown in Table 2 was determined using the chi-square test. The results of both methods described above are seen to be identical in the case that all centers provided feedback on specific parameters (no blanks; e.g., Table 2; total PCI, acute PCI, and/or in the presence of infarction, etc.).

Results and discussion

All coronary interventions (Table 3; Figs. 3, 4, and 5)

A total of 53,808 diagnostic CA and 20,295 PCI were carried out in Austria in 2011 (Figs. 3 and 4). In 2010 and 2011, five and four centers, respectively, performed less than 400 CA per year and nine and seven centers, respectively, performed less than 200 PCI per year (Fig. 5).

In comparison with Austria's neighboring states (Fig. 4), Switzerland was on the fast track in 2011 with

Table 3 Cardiac catheter interventions in Austria, 2008–2011. Austrian questionnaire, "Diagnostics and electrophysiology" (pooled analysis)

Number		2008	2009	2010	2011
Diagnostic angiographies (CA)		51,292	52,149	55,138	53,808
—Deaths CA total		36	47	67	58
CA without shock	In infarction	7,527	7,409	7,286	8,199
—Deaths CA without shock		9	13	30	30
CA with shock	In infarction	388	494	487	443
—Deaths CA with shock		14	27	24	23
Myocardial infarctions as complication		11	12	32	26
—Defined by Q wave		0	1	3	7
—Defined by TnI or CK		10	11	30	19
Punctures as of arm		ns	ns	ns	9,475
Reversible neurological complications		24	29	25	33
Irreversible neurological complications		6	2	5	12
Puncture closure devices		22,417	25,845	32,316	29,871
Vascular complications		276	305	339	282
—With surgery or transfusion		62	63	83	47
—With thrombin injection		69	64	90	68
Contrast agent reactions		88	121	100	103
Left heart ventricular angiographies		20,231	21,888	20,886	19,194
Right heart catheter		3,462	3,838	3,588	3,668
Myocardial biopsies		307	420	244	265
Diagnostic	Electrophysiology	2,890	2,612	2,821	2,879
Ablations		*2,166*	*2,206*	*2,553*	*2,787*
DEVICE implantations		1,739	1,567	1,889	1,715
NOGA mapping		68	50	43	ns

Substantial differences are italicized
CA coronary angiographies, *ns* not sampled

Table 4 Cardiac catheter interventions in Austria, 2008–2011. Austrian questionnaire, "Non-acute PCI" (pooled analysis)

	2008	2009	2010	2011
Non-acute PCI				
PTCA = non-acute PCI	13,041	13,073	13,828	13,349
—Deaths PCI non-acute total	36	29	27	36
Myocardial infarctions as complication	177	187	150	102
—Defined by Q wave	*22*	*34*	*17*	*7*
—Defined by TN or CK	155	146	125	56
Punctures as of arm	ns	ns	ns	2,474
Reversible neurological complications	13	15	16	17
Irreversible neurological complications	*2*	*3*	*6*	*7*
Puncture closure devices	9,010	9,118	10,318	9,350
Peripheral vascular complications	103	230	159	122
—With surgery or transfusion	35	49	31	20
—With thrombin injection	22	38	32	45
Contrast agent reactions	36	49	48	23

Substantial differences are italicized
PCI percutaneous coronary interventions, *PTCA* percutaneous transluminal coronary angioplasty, *ns* not sampled

Table 5 Cardiac catheter interventions in Austria, 2008–2011. Austrian questionnaire, "Acute PCI in myocardial infarction" (pooled analysis)

	2008	2009	2010	2011
Acute PCI in myocardial infarction				
Acute PCI	6,686	6,783	6,466	6,946
—Deaths PCI acute total	169	169	160	126
PCI in infarction without shock	6,326	6,380	6,006	6,539
—Deaths	64	75	44	57
PCI in infarction with shock	360	403	460	407
—Deaths	105	94	116	69
Punctures as of arm	ns	ns	ns	1,091
Reversible neurological complications	4	7	12	11
Irreversible neurological complications	3	4	8	7
Puncture closure devices	2,912	3,741	3,962	3,661
Peripheral vascular complications	65	84	82	68
—With surgery or transfusion	18	26	28	19
—With thrombin injection	5	18	18	16

Substantial differences are italicized
PCI percutaneous coronary interventions, *ns* not sampled

2,564 PCI per million inhabitants (pmi) as compared with Austria with 2,407 PCI pmi [6]. While increasing absolute figures in that year, Switzerland continued to maintain a higher, 46.3 % PCI/CA ratio (Austria: 37.2 % "therapeutic yield"). The percentage in the Czech Republic was 40.6 % in 2011 (Georg Norman, personal communication).

In all German states, performance numbers for CA and PCI were higher (Figs. 3 and 4) than in Austria in 2010 [7]. For the first time, no corresponding figures have been provided by Germany for the year 2011. A poll conducted by the German Cardiac Society (Deutsche Gesellschaft für Kardiologie) indicated 10,634 CA pmi—a sign of decrease and possibly the beginning of stagnation. However, this publication presented 4,016 PCI pmi, translating to a slight increase as compared with the preceding year and a German PCI/CA ratio of 37.8 % in 2011 as compared with 37.0 % in 2010 [8].

Acute coronary interventions (Tables 2–7; Fig. 6)

Over the 2003–2011 interval, 18–24 centers in Austria reported the target of 36 interventions per center and year for significant ST-segment elevation myocardial infarction (STEMI). The best rate presently dates back to 2006; the total has constantly been 23 centers since 2009.

Over the period between 2008 and 2011, the number of acute PCI cases increased slightly from 33.9 to 34.2 % of all PCI cases (Table 2; no blanks), rising to 6,946 cases and the highest level to date in 2011 (Table 6). In turn, the

Table 6 Cardiac catheter interventions in Austria, 2008–2011. PCI—original questionnaire of the European Society of Cardiology. Coronary interventions (pooled analysis)

Number	2008	2009	2010	2011
Total PCI	19,727	19,856	20,294	20,295
Bifurcation PCI	Blank	Blank	912	830
Single-session multiple-vessel PCI	3,341	3,096	2,825	2,749
PCI in infarction	6,686	6,783	*6,466*	*6,946*
—PCI in STEMI	*3,677*	3,440	3,354	*3,306*
Ad hoc = single-phase	16,252	16,826	15,788	15,681
Arm puncture	*1,484*	*2,603*	*3,434*	*3,565*
Puncture closure devices	14,708	13,775	14,870	13,011
Subsequent myocardial infarction	177	187	150	104
Iatrogenic main stem dissection	*12*	10	16	*19*
Emergency surgery	15	11	23	16
PCI mortality	205	198	187	162
Emergency surgery—mortality	*7*	*4*	*6*	*1*
Stents	17,340	17,753	18,561	18,427
—Drug-eluting stents	*11,579*	12,221	13,847	*14,166*
—Drug-eluting balloon	ns	*253*	*370*	*757*
—Main stem stents	364	348	398	374
—Multiple stents	5,048	5,510	5,522	4,911
PCI for in-stent restenosis	*1,263*	*996*	*849*	*921*
—PCI for chronic hyperplasia	*750*	*659*	*586*	*566*
—PCI for stent thrombosis	*130*	*98*	*105*	*74*

Substantial differences are italicized
PCI percutaneous coronary interventions, *STEMI* ST-segment elevation myocardial infarction, *ns* not sampled

Table 7 Cardiac catheter interventions in Austria, 2008–2011. Original questionnaire of the European Society of Cardiology, special techniques (pooled analysis)

Special techniques	2008	2009	2010	2011
Rotablator	278	292	265	336
Clot catchers/removers	1,065	1,405	1,596	1,896
Intracoronary pressure measurement	1,548	1,649	1,732	1,908
IVUS = diagnostic ultrasound	1,096	1,036	961	910
Intra-aortic balloon pump in PCI	175	178	208	147
Other new devices	133	241	75	65
Glycoprotein IIb/IIIa receptor AT	3,565	2,830	2,530	2,223
Thrombin inhibitor	598	486	672	1,065
Optical coherence tomography	113	137	263	270
Stem cell therapy with catheter	3	0	0	ns
Stereotactic wire navigation	33	13	4	ns
Alcohol septal ablation (PTSMA)	13	30	9	14

Decreases and increases are marked in bold and italic, respectively
IVUS intravascular ultrasound, *PCI* percutaneous coronary interventions, *PTSMA* percutaneous transluminal septal myocardial ablation, *ns* not sampled

proportion of PCI for STEMI dropped from 58.8 % of all acute PCI cases to 52.3 % ($p<0.001$) over the same period (Table 2; analysis excluded five blanks). Thus, a larger number of PCI were performed as defined by "acute,"

Table 8 Interventions in Austrian cardiac catheter laboratories, 2008–2011. Austrian questionnaire, "Non-coronary interventions" (pooled analysis)

Non-coronary interventions	2008	2009	2010	2011
Renal/leg artery interventions	467	522	398	637
Carotid artery intervention	131	125	80	94
Mitral valvuloplasty	12	10	6	43
MitraClip (EVALVE)	ns	7	20	39
Interventional aortic valve implantation	144	188	292	397
—Only balloon	23	30	50	21
—Valve transapical	13	45	18	39
—Valve transfemoral	108	133	224	356
—Edwards SAPIEN	ns	39	31	98
—CorValve	ns	139	214	297
PFO/ASD/PDA catheter closure	296	316	274	236
Renal denervation (PRD = RND)	ns	0	35	104

Decreases and increases are marked in bold and italic, respectively
PRD percutaneous renal denervation, *ns* not sampled

although the proportion of STEMI PCI dropped (Table 6). This may have been caused by a more liberal definition of "acuteness" due to clinical and enzymatic findings, together with an improved availability of resources.

Rather unexpectedly, the number of diagnostic interventions for shock reported in Austria decreased from 494 in 2009 to 443 cases in 2011 (Table 3; pooled analysis). Accordingly, therapeutic consequences arose from the majority of these cases, as high-level stagnation was observed over the past years in terms of PCI for shock (Table 5; Fig. 6). For example, the development of PCI for shock with intra-aortic balloon pump (IABP) support in 2010–2011—a drop from 0.95 to 0.77 % of all PCI; non-significant; excluding three blanks; Tables 2 and 7—was to be expected on account of international studies. The IABP Shock II Trial refuted the previously postulated absolute necessity attached to the balloon pump [10]. PCI-supported lifesaving in shock as a result of cardiac infarction continues to be glaring = outstanding, whereas the numbers and kinds of interventions have obviously been stabilized at an internationally high level [10].

In the framework of PCI for acute and—even more frequently—subacute myocardial infarction, intracoronary thrombus growth may necessitate the use of mechanical *PCI "clot catchers/removers"* (Table 7). This application resulted in a significant increase from 5.5 % of clot catchers/PCI in 2008 to 9.6 % in 2011 ($p<0.001$; excluding two blanks; Table 2).

The number of acute interventions has a crucial impact on the amount of complications and correspondingly affects percentages (Tables 5 and 6).

Complications, including mortality (Tables 2–6; Fig. 1)

The total of PCI mortality reported by the centers was constant over the 2009–2011 period and amounted to

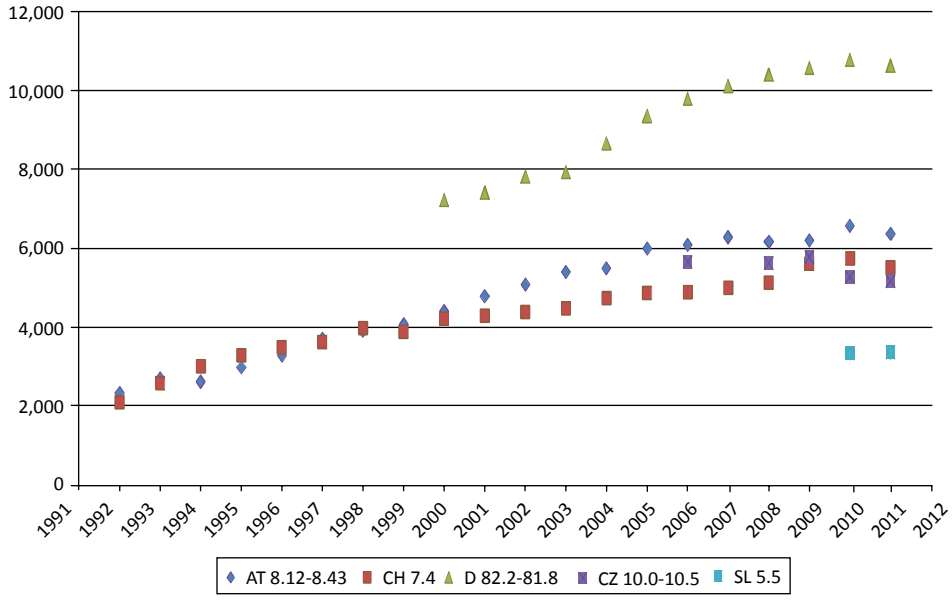

Fig. 3 Number of diagnostic angiographies per million inhabitants in Austria (AT; 8.12 million inhabitants in 2005 and 8.4 million inhabitants until 2011), Switzerland [5, 6] (CH; 7.4 million; 1992–2011), Germany [7, 8] (D; 81.8 million; 2000–2011), the Czech Republic (CZ; 10.0 million; 2006, 2008–2011), and Slovakia (SL; 5.5 million; 2010 and 2011)

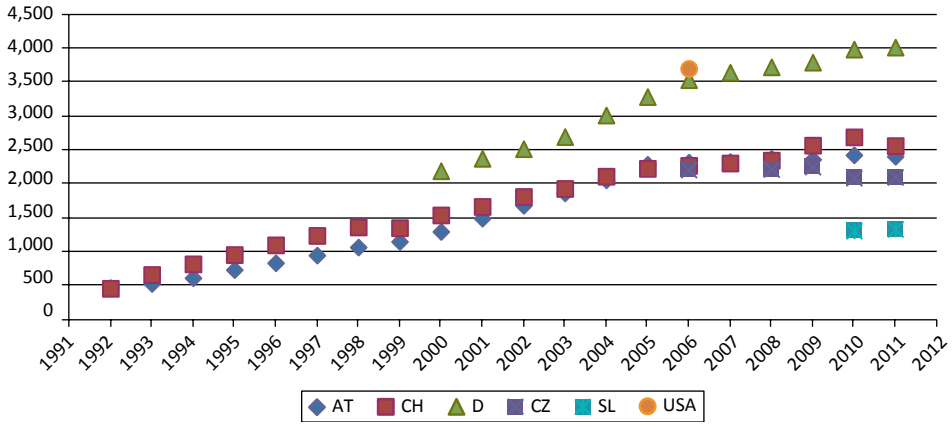

Fig. 4 Number of percutaneous coronary interventions per million inhabitants in Austria (AT; 8.12 million inhabitants in 2005 and 8.4 million inhabitants until 2011), Switzerland [5, 6] (CH; 7.4 million; 1992–2011), Germany [7, 8] (D; 81.8 million; 2000–2011), the Czech Republic (CZ; 10.0 million; 2006, 2008, 2009–2011), the United States in 2006, and Slovakia (SL; 5.5 million; 2010 and 2011)

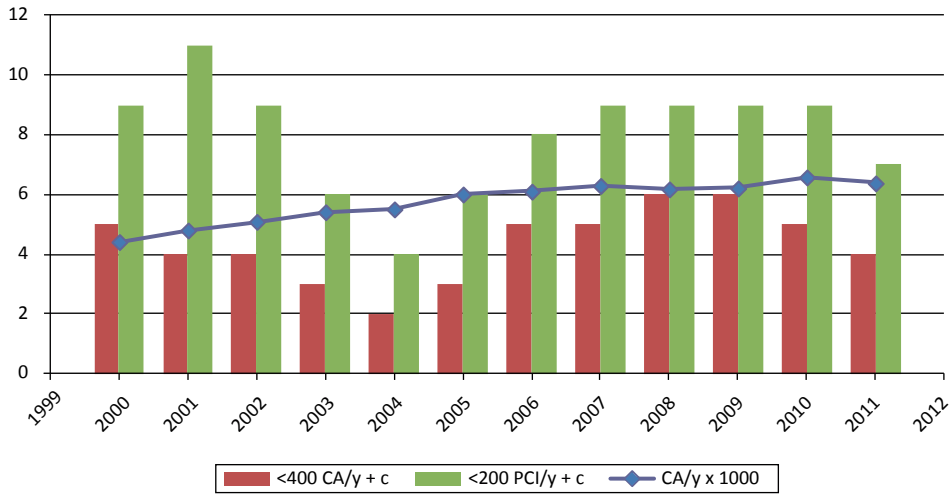

Fig. 5 Number of centers conducting <400 diagnostic interventions annually [<400 coronary angiographies (CA)/year and center] and <200 percutaneous coronary interventions (PCI) annually (<200 PCI/year and center), in relation to the numerical development of diagnostic interventions per year and per 1,000 inhabitants (CA/y × 1,000) in Austria, 2000–2011. A beneficial development is seen up to 2004, and then an increase in small centers until 2009 with stagnating numbers of cases, and finally a consolidation

0.92 % in 2010 and 0.80 % (Table 2; Fig. 1) in 2011. Replacing reported "zeros" that appeared improbable with "blanks," the total mortality summed up to 1.5 %. The (actually reported) 0.8 % total of PCI mortality in 2011 was made up of 0.27 % mortality (36/13,349; Table 4) for non-acute PCI and 1.8 % mortality (126/6, 946) for acute PCI. By nature, a considerably higher rate of mortality resulted from acute PCI for infarction with cardiogenic shock (69/407 = 16.9 %) than acute PCI for infarction without shock (57/6.539 = 0.87 %; Table 5).

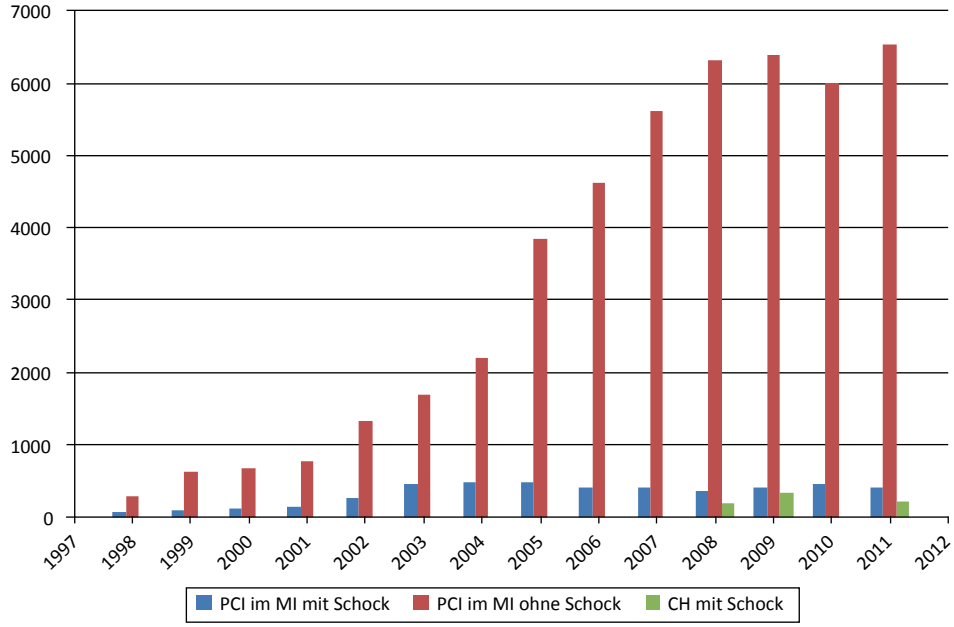

Fig. 6 Number of acute percutaneous coronary interventions for myocardial infarction (PCI in MI) with/without shock in Austria, 1998–2011 (as of 2002: mandatory allocation of acute PCI: either "in shock" or "without shock"; reports of acute PCI not classified accordingly over preceding years are not represented)

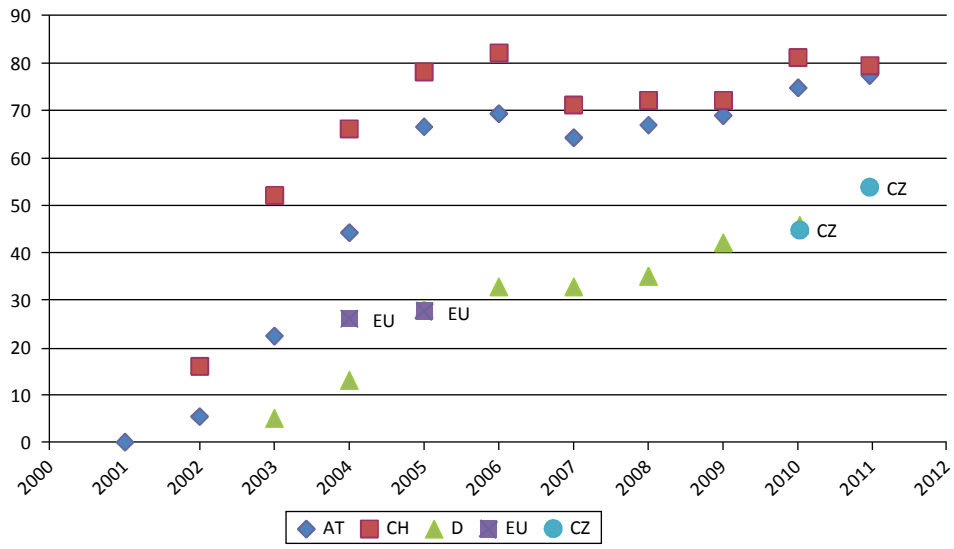

Fig. 7 Percentage of percutaneous coronary interventions with drug-eluting stents (DES) as relating to the number of stent cases (DES/stent %) in Austria (AT; 2002–2011), Switzerland [5, 6] (CH; 2002–2011), Germany [7, 8] (D; 2003–2010), the European Union (EU; average 2004, 2005, and 2010), and the Czech Republic (CZ; 2010 and 2011)

The (included) mortality resulting from emergency surgery for PCI complications in Austria in 2011 applied to one of the 16 patients undergoing acute surgery (16 out of 20,295 PCI cases were given acute emergency surgery, translating to 1 case out of 1,268 PCI). With regard to elective PCI, international figures of previous years referred to an emergency surgery rate of 1 out of 300 PCI, consecutive mortality of 10–15 %, and an emergency surgery rate of 0–1 % (mean value: 0.31 %) in STEMI PCI. Although 16 criteria were seen in 2012 to be fulfilled to perform PCI without on-site cardiac surgery [11], no substantial difference was identified in PCI results in 2013 [12], regardless of whether PCI was done with or without on-site cardiac surgery [11, 12].

In 2010/2011, 67/58 patients (0.12 %/0.11 %) died after diagnostic CA (Table 3; pooled analysis). The feedback rate was fragmentary, but has improved since. Cases have been included in which death emerged in interventions for acute infarction before acute PCI, yet in the course of or immediately after diagnostic angiography. In these cases, the feedback rate was higher: mortality *AFTER diagnostic CA and BEFORE planned PCI for acute cases* (0.61 %; 53/8,642) was composed of mortality for *diagnostic CA BEFORE planned PCI* for infarction with cardiogenic shock (5.2 %; 23/443), in which mortality is substantially higher, and mortality after *diagnostic CA BEFORE planned PCI* for infarction without shock (0.37 %; 30/8,199; Table 3; pooled analysis).

In 2011, five patients (0.009 %) thus died in Austria after *diagnostic CA*, in whom no acute situation was on hand (Table 3; pooled analysis).

The number of seven reported irreversible neurological complications after non-acute PCI (0.052 %; 7/13,349) in 2011, as compared with 0.015 % (2/13,041) in 2008, is worthy of mention (Table 4). With regard to acute PCI for myocardial infarction, the number of 11 reported reversible neurological complications after this intervention

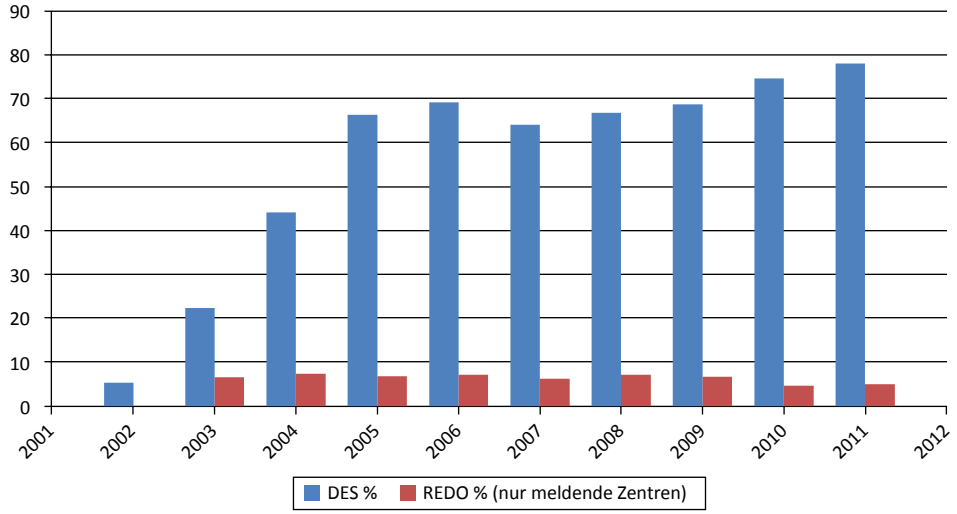

Fig. 8 Percentage of drug-eluting stent (DES) cases as relating to the total of stent cases (DES/stent %) and percentage of interventions for restenosis (only reporting centers, i.e., no blanks) as relating to the total of PCI cases (REDO/PCI %) in Austria, 2003–2011. REDO cases were not yet sampled in 2002

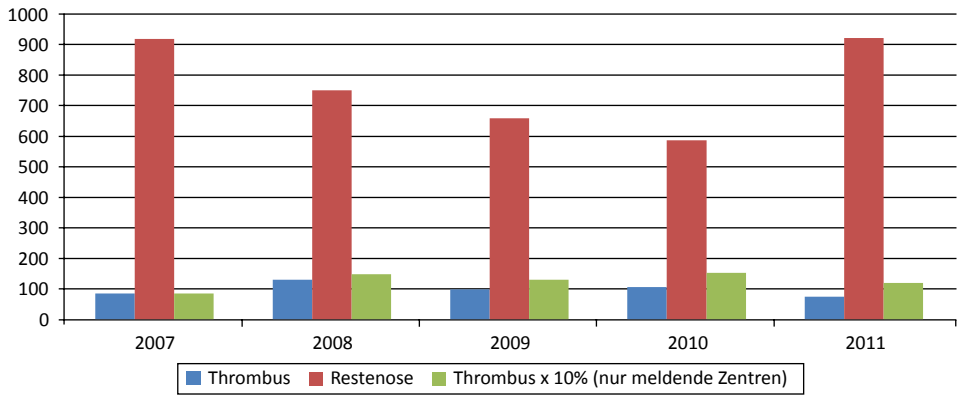

Fig. 9 Number of interventions for restenosis (*n*) and number (*n*) and percentage (thrombus × 10 %) of etiological thrombi (only reporting centers, i.e., no blanks) as relating to the total of REDO cases in Austria, 2007–2011

(0.158 %; 11/6,946) in 2011 is striking as compared with 0.06 % (4/6,686) in 2008 (Table 5).

The proportion of severe bleedings (due to surgery and/or transfusion in need of care) relating to the total of reported bleedings in 2010–2011 amounted to 24.5–16.7 % in *diagnostic CA*, to 19.5–16.4 % in non-acute PCI, and to 34.2–27.9 % in acute PCI. As in the preceding years, this complication was more serious after acute interventions than after routine interventions in 2011, presumably due to additionally required coagulation-promoting drug (Tables 3–5; pooled analysis of reporting centers only).

Stents (Tables 2 and 6; Fig. 7)

Over the 2005–2011 period, the stent-per-PCI ratio remained constant in Austria as well as other countries, stents being implanted in 18,561/18,427 cases (91.5 %/91.0 % of PCI cases) in Austria in 2010/2011. However, a joint Austrian and Swiss high-level stagnation emerged by 2011 in terms of previously divergent percentages in the ratio between bare-metal stents (BMS) and drug-eluting stents (DES), expressed as the share of DES per stent (Table 6; Fig. 7). By 2010/2011, DES held a share of 74.6 %/78.0 % of all stent cases since 2006 (69.2 % that year) in Austria and in Switzerland (71–82 %). Since 2006, variation in the application rates between the individual Austrian centers continued to be considerable (38.2–100 % in 2006; 33.3–90.7 % in 2007; 32.5–93.3 % in 2008; 41.4–97.0 % in 2009; 32.7–96.7 % in 2010, and finally 56.9–100 % in 2011). In Austria, the lower threshold of application increased in general and exceeded the German average values by 2010 [7]. An analysis excluding blanks revealed increases of 87.9 % (2008) to 90.8 % (2011) stents per PCI ($p<0.001$; Table 2; no blanks) and 66.9–76.9 % DES per stent ($p<0.001$; Table 2; no blanks).

According to communications by representatives of the industry (Reinhard Walczer and Gerin Hutterer; April 2, 2013, on behalf of EUCOMED), 23,800 DES and 3,300 BMS were "delivered" in Austria in 2012, corresponding to an 87.8 % DES-per-stent ratio (233,800/27,100).

Re-intervention (REDO) for chronic hyperplasia or chronic stent thrombosis (Tables 2 and 6; Figs. 8 and 9)

The analysis shown in Table 2 excluding blanks (and summarizing 2-year intervals) indicates a significant decrease in all cases of re-intervention for chronic in-stent restenosis (REDO) from 7.4 % in 2008 to 5.4 % in 2009 ($p<0.001$). Identical assessments in subsequent years up to 2011 showed no significant trend (5.2 % share of REDO). Furthermore, no significant change in chronic

hyperplasia was observed in similar analyses between 2008 and 2011 (85.6–88.1 % share in all interventions for in-stent restenosis; 16 blanks; Table 2). Between 2008 and 2011, however, the share of etiologically chronic stent thromboses was declining (14.4–11.9 %; 16 blanks; Table 2), yet not significantly so (also cf. Table 6). This does not apply to acute stent thromboses occurring in the course of or immediately after implantation.

In view of a specific statistical analysis, Fig. 8 presents the "year-by-year" percentages of interventions for restenosis since 2003 (reporting centers only, i.e., excluding blanks) as relating to the total of PCI cases (REDO/PCI %). These findings are compared with the increasing percentages of DES cases as relating to the total of stent cases (DES/stent %) over the 2002–2011 period. REDO cases were not yet sampled in 2002. These cases subsequently fluctuated between 6.6 and 7.4 % of all PCI cases in 2003–2004 and between 4.6 and 5.0 % in 2010–2011—this analysis thus also yielded merely slight changes of values over the past years (also cf. Table 6).

Reflecting another specific analysis as of 2007, Fig. 9 shows the annual absolute numbers of reported interventions for restenosis (again reporting centers only) as relating to absolute numbers of reported stent thromboses, excluding blanks as relating to reported causes of restenosis. This analysis showed a fluctuating share of etiological stent thromboses from 8.5, 14.8, and 13.0 to 15.2 % and finally 11.9 % of all REDO in 2011—again, no clear trend was to be identified with this kind of analysis (also cf. Table 6).

Over time and comprehensively, the advantages of DES are suspected to be compensated by more sophisticated interventions (longer lesions, thinner vessels, etc.). Evidentially, one disadvantage associated with DES is the requirement of dual platelet aggregation inhibition. Incidentally, the factual capability of being externally influenced associated with subsequent and potentially lethal stent thrombosis has already expanded into the bestseller lists of popular fiction [13].

Special techniques and innovations (Tables 2, 6, and 7)

Recent concepts have included the so-called "bioresorbable vascular scaffolds." As of 2012, our questionnaire has thus incorporated stents that are biodegradable by way of a bioresorbable matrix or as such (e.g., consisting of poly-L-lactic acid) as a separate parameter. With regard to other parameters that had been included before, there was sincere concern as to the comprehensive preciseness of feedback (Linz, November 2012): the definitions were sharpened with regard to bifurcation PCI (first sampled for 2011; currently, 4.1 % of PCI; 830/20,295) and transarterial valve implantation (TAVI; sampled since its launch in 2007). We thus expect "fostering the model" to result in improved preciseness (as observed in the past). Reviewing reporting centers alone in 2011, the bifurcation PCI rate amounted to 6.7 % (830/12,439; 26 reporting centers).

In part, various "coronary niche applications" have clearly increased

Clot catchers/removers were applied in 9.6 % of (predominantly acute) PCI cases in 2011, thus reflecting a significant increase as compared with 5.5 % in 2008 ($p<0.001$; excluding two blanks; Table 2). This corresponds to a continuous increase from 148 to 1,896 cases over the 2002–2011 interval (Table 7).

Recording of *arm punctures and non-femoral punctures* in Austria was initiated in 1999. These procedures escalated from 8.2 % (2006) to 13.1 % (2009) and finally to 17.6 % (2011) of PCI. Excluding blanks from the analysis, the percentages were 18.2 % in 2011 as compared with 7.7 % of non-femoral punctures/PCI in 2008 ($p<0.001$; excluding one blank; Tables 2 and 6). The French part of Switzerland reported 32 % and the German region 6 % of excluding arm punctures in 2009 [6]. This high level of variation was also reflected in the Austrian centers. In 2011, 5 out of 36 centers performed more than half of their procedures via non-femoral punctures, one center even reporting 100 % (37/37).

The fact should be considered that arm punctures and/or non-femoral punctures are to result in a relative drop in reporting the number of femoral vascular closure systems.

In 2003, intracoronary pressure measurement (fractional flow reserve) was applied in 1.6 % of PCI. The average percentages were 8.5 and 9.4 % of PCI in 2010 and 2011, respectively (Table 7), with an inter-center variation of 0–27.3 % in 2010 and 0–36 % in 2011. In that year, eight centers performed *intracoronary pressure measurement* in no single PCI case and 15 centers in less than 10 % of PCI cases. An analysis excluding blanks resulted in a significant growth from 7.2 to 9.9 % in the share of pressure measurements per PCI over the 2008–2011 period (excluding one blank; Table 2). This development correlates with the international trend [14].

Optical coherence tomography (OCT) facilitates a sophisticated degree of visualization within the internal vascular structure at the cost of increased expenditure. In Austria, OCT was recorded in 60 cases, for the first time in 2007, and, as of 2009 with reports from 10 centers, reached a preliminary peak in 2011 with 270 cases in 11 centers (Table 7). An analysis excluding two blanks indicated a significant increase from 0.6 % (2008) to 1.5 % (2011) of OCT/PCI ($p<0.001$; Table 2).

The "*drug-eluting balloon*" was first sampled in 2009 with 253 cases, increasing to 757 cases by 2011 (Table 6).

Other applications recently showed rates of increase

Positioning of *stents in the left main stem* (including the "protected left main" constellation) had increased from 1.2 to 2.1 % of stent cases over 2003–2006, subsequently remaining constant in this number range (pooled analysis; Table 6). An analysis excluding one blank revealed no significant change in 2011—2.2 % of all stent cases—as compared with 2008 (Table 2). This may serve as a typical

example of high-level stagnation and probably a result of rare, yet balanced, indications.

A pooled analysis of the number of *puncture closure devices* applied between 2003 and 2011 indicated rigorous growth both as to diagnostic cases (13.4–55.5 %) and PCI cases (48.3–64.1 %). In 2011, 52.7 % of acute and 70.0 % of elective PCI cases were finally concluded with a *puncture closure device*, whereas applications in acute cases strongly increased only in the past years (from 2,912 in 2008 to 3,661 in 2011; Table 5).

In analyses excluding five blanks, applications of reported puncture closure devices increased to a significant extent from 72.0 % of all PCI interventions in 2008 to 74.8 % in 2010 (Table 2; $p<0.001$; 2010 as compared with preceding year) and then decreased significantly from 74.8 % in 2010 to 70.8 % in 2011 (Table 2; $p<0.001$; excluding five blanks). The reason for the process of stagnation or drop in implanted puncture closure devices is to be seen in the increase in non-femoral punctures that do not require an embolus to be implanted concludingly.

Calculating the allocation of this embolus as a percentage of exclusively femoral rather than all punctures—total of 20,295 PCI cases minus 3,565 cases of *non-femoral puncture* = 16,730—a pooled analysis resulted in 77.8 % (13,011/16,730) of puncture closure devices post PCI for 2011. In 2009, the percentages were 62 and 69.4 % of PCI cases in Switzerland and Austria, respectively. After observations to this effect had been initiated in 1997, a plateau was reached in 2005 in terms of the two countries' application rates [6].

Since 2005, the initial year in which the use of *direct thrombin inhibitors* in PCI was recorded, the application rate has increased annually from 1.1 % in 2005 to 5.2 % in 2011 (pooled analysis; Table 7). An analysis excluding six blanks identified an application rate growing significantly from 4.1 to 5.3 % from 2008 to 2011 ($p<0.001$; Table 2). Glycoprotein IIb/IIIa receptor antagonists (GP blockers) were not displaced suddenly, yet a decrease did take place from 18.1 % of GP blockers per PCI in 2008 to 11.0 % in 2011 (pooled analysis; vide infra and Table 7).

Other applications recently showed declining rates

The share of interventions applying GP blockers for platelet aggregation inhibition in the framework of PCI reached a peak in 2000 with 22.1 % of PCI cases, from then on dropping continuously to 11.0 %, the lowest value since 1998, in 2011 (pooled analysis; Table 7). An analysis excluding four blanks resulted in a significant decrease from 17.2 % (2008) to 11.8 % (2011) ($p<0.001$; Table 2). Switzerland also reported a dramatic decline from 24 % in 2007 to 17 % in 2009 [6]. Since 2009, several Austrian centers have completely done without the use of GP blockers in the framework of PCI. This would seem to introduce the expected displacement of GP blockers by the application of *direct thrombin inhibitors* (launched in 2005; 5.3 % increase in direct thrombin inhibitors until 2011; excluding six blanks; vide supra and Table 2).

An analysis excluding five blanks revealed a decline of 0.90 % (2008) to 0.42 % (2011) for "other new devices" sampled in collective form (and thus not mentioned by name; $p<0.001$; Table 2). Of course, this may reflect the collective decrease in attempts at innovation.

Intracoronary innovations in terms of non-coronary heart disease interventions included *intracoronary alcohol septal ablation* for hypertrophic cardiomyopathy—previously termed transcoronary ablation of septal hypertrophy, then percutaneous transluminal septal myocardial ablation—which has been sampled for four years. This is a treatment option for rare diseases, and the treatment volume has remained low. One of the university clinics gave no feedback in 2010, yet contributed five cases in 2011 (Table 7).

Intracoronary ultrasound diagnosis (IVUS), with 175 cases recorded in 1997, showed stagnating figures between 2002 (768 cases) and 2006 (746 cases), while becoming rarely applied altogether. However, complete feedback has indeed come in from the respective centers (Table 2; no blanks). The analysis yielded a decline from 5.6 % (2008) to 4.5 % (2011) of IVUS per PCI ($p<0.001$; Table 2). The application rate culminated in 2008 with 1,096 cases (Table 7).

The *Rotablator* outlasted at a continuously low level (233 cases in 2002, 336 cases in 2011; Table 7) and increased significantly from 1.4 % (2010) to 1.8 % (2011) of PCI ($p<0.01$; excluding one blank; Table 2).

"Obsolete innovations in the cath lab"

The following innovations of previous years were no longer applied in Austria and thus not sampled (n=number of years from last application to 2011): catheter-guided stem cell therapy ($n=3$; Table 7), intracoronary laser ($n=10$), therapeutic intracoronary ultrasound ($n=9$), therapeutic medullary stimulation ($n=9$), transmyocardial laser ($n=7$), brachytherapy ($n=6$), and atherectomy ($n=5$)—altogether finally passé by 2011. *Closure of the left atrial auricle*, not applied between 2005 and 2008, has celebrated a comeback in between (two closures in Innsbruck in 2011) and is to be re-integrated into the questionnaire in 2012. In this connection, 114 new cases were reported in 2011 in Switzerland due to the launch of a new device [6]. Stereotactic wire navigation (Table 7) was no longer sampled as of 2011 and is now only applied in one laboratory in Vienna in the framework of electrophysiological investigations.

Electrophysiological data (Table 3)

The Rhythmology Working Group of the ÖKG (www.rhythmologie.at) has been assessing electrophysiological activities in Austria in collaboration with several public institutions (BIQS/GÖG/ÖBIG). In parallel, we have maintained our recording and publishing tradition from a purely medical perspective: in 2011, the ablation-to-electrophysiology ratio (the "therapeutic

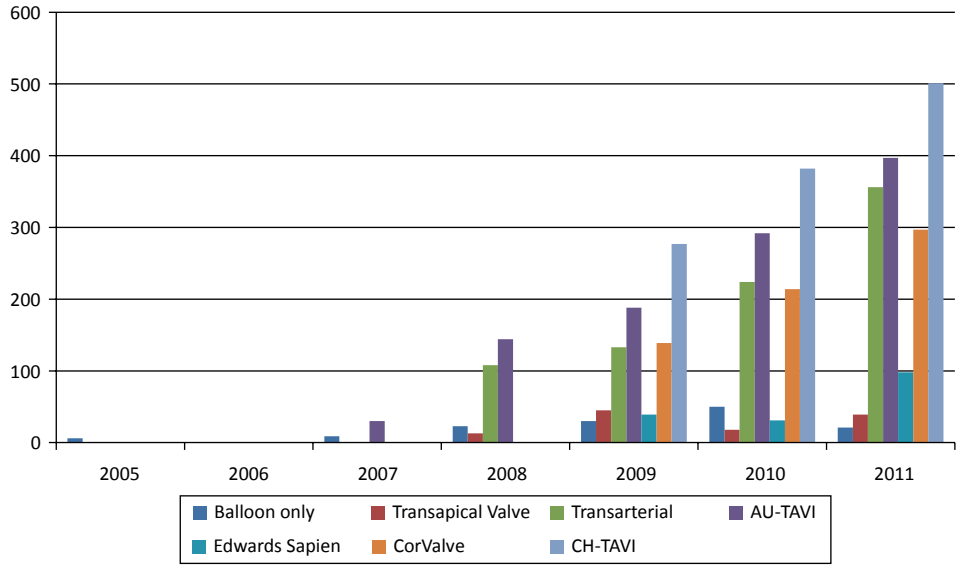

Fig. 10 Number of "transcatheter aortic valve implantations" (TAVI) in Austria, 2007–2011, applying Edwards SAPIEN or CorValve valves via a transapical or transarterial approach. Number of interventions via balloon at the aortic valve, 2005–2011; number of TAVI interventions in Switzerland [5, 6], 2009–2011

yield") culminated to 96.8%—the highest (best) value so far (2004–2010: 64.8, 77.6, 87.8, 72.3, 74.9, 90.4). Rates of ablations in patients with atrial fibrillation (AF) are included in this value. In the 2007–2011 interval, 1,642/1,739/1,567/1,889/1,715 pacemakers (with/without defibrillators) were implanted, and 1,111–1,104 pacemaker interventions (constant numbers since 2004) were carried out in the catheter laboratories (feedback from 24 centers; Table 3). A separate nationwide statistical assessment of ablations in AF patients in Austria is an issue of future interest.

Non-coronary interventions and innovations (Tables 3 and 8; Fig. 10)

Renal artery ablation (*percutaneous renal denervation*; Table 8) emerged as a new treatment modality in 2010, applied for the neuroregulation of hypertension with 35/104 cases in 2010/2011. This treatment is to be distinguished from renal artery stent implantation for local atherosclerosis (Table 8). Twenty cases were reported in Switzerland in 2011 [6]. In this connection, the Transcatheter Renal Denervation Registry has been established in Graz (Dr. Helmut Brussee; Universum Innere Medizin; September 2011).

Non-coronary interventions, such as myocardial biopsies (Table 3) or defect closures (Table 8), increased in 2008 and 2009, while subsequently diminishing until 2011. These interventions were also declining in Switzerland, in which 880/875/756 defect closures were performed in the years 2009–2011 [6]). In Austria, the effect encountered with *intracoronary alcohol septal ablation*—a decline due to the processing of accumulated cases (Table 7)—may possibly have also applied to *defect closures* (316/274/236 cases in 2009–2011; Table 8). In turn, an audit revealed that no actual decline has been effective in *endomyocardial biopsies* in Austria (420/244/265 cases in 2009–2011). Rather, one center had simply reported exaggerated numbers (Table 3).

A total of 12/24/9/19/12/10/6/43 cases of *mitral valvuloplasty at the catheter table* were shown for 2004–2011 (Table 8). The increase was in part due to 7/20/39 *MitraClip (previously EVALVE) implantations* in 2009–2011 (Table 8). This intervention is based on surgical "edge-to-edge repair" for mitral valve prolapse and has shown promising international short-term results. In 2011, Switzerland reported 104 cases of transcatheter mitral valve repair after 67 cases in 2010 [6].

Percutaneous aortic valve replacement therapy (Table 8, Fig. 10)

With regard to the issue of competence in terms of TAVI—the issue of surgery vs. cardiology—the respective board of arbitration has recently issued a decision in support of the latter, as the term catheter is used in the Continuing Professional Education regulations for cardiologists, yet not for heart surgeons (Dr. Ernst Bruckenberger, personal communication, November 8, 2012).

As of 2007 (30 reported cases), and with clearly increasing applications overall (2009–2011; 188/292/397 percutaneous cases), 133/224/356 cases using a transapical approach and 45/18/39 cases applying percutaneous aortic valve replacement therapy were reported in Austria over that period (Fig. 10; Table 8).

Austria ranks among Europe's top performers in 2011, with 47 percutaneous aortic valve implantations pmi. This figure results from our own data (Table 8). In all, 12 centers reported a total of 397 cases of percutaneous aortic valve replacement therapy, yet we lack "purely surgical percutaneous reports," mainly applying a transapical or transaortic approach.

The Austrian Federal Institute for Quality in Public Health (Bundesinstitut für Qualität im Gesundheitswesen; BIQG) allocated 392 cases in 2011 (under the num-

ber: XN010; replacement of aortic valve—percutaneous, interventional). Calculating this number as a share in all (openly surgical plus interventional) cases of aortic valve replacement, the BIQG reported a TAVI share of 33 % for 2011 (392/1,187) [15].

The Austrian TAVI online registry (Robert Meier; Linz, November 23, 2012; interventional ÖKG meeting) recorded reports from 11 centers with 315 cases of percutaneous aortic valve replacement therapy. According to communications by representatives of the industry (Linz, November 23, 2012), 465 cases of aortic valve replacement therapy were carried out in Austria in 2011. According to E. Maurer (Linz, November 23, 2012; interventional ÖKG meeting), the European average in 2011 was 40.9 cases pmi, with 96 and 80 cases pmi in Germany and Switzerland, respectively. In Switzerland (Fig. 10), 18/127/277/382/501 cases of TAVI were published in the 2007–2011 period [6]. Relating this information to the Swiss calculation, 63 TAVI pmi (501 TAVI/7.95 million inhabitants) were performed in 2011. Based on the figures indicated by the industry (465 cases), 55 TAVI pmi were carried out in Austria in 2011.

The German Aortic Valve Registry covered 92 out of 99 centers and reported a 23 % share of TAVI (3.188/13.860) in all (surgical and interventional) cases of aortic valve replacement until 2012. This corresponds to 3,188/81.84 = 30.0 pmi [15]. According to H. Thiele (Cardiology Congress, Innsbruck, March 1, 2013), 3,875 cases of TAVI—2,694 arterial and an additional 1,181 apical cases—were carried out in Germany in 2011. This sums up to 28.9 % of all 13,860 cases of aortic valve replacement (3,188/13,860), i.e., 3,875/81.84 = 47.4 cases pmi. Referring to the AQUA Institut, the "Deutscher Herzbericht" of the German Heart Foundation (Deutsche Herzstiftung) reported 88 TAVI pmi in a total of 81.84 million inhabitants [8].

The relatively low EU average is due to member states such as Romania, Bulgaria, and Lithuania, in which virtually no TAVI procedures have been performed as yet. Due to occasional financing, a very low number of TAVI have also been carried out in other Eastern European countries, particularly in Poland, with more than 40 million inhabitants. In turn, Austria is not in the lead as compared with Western Europe and, according to data presented at the 2012 Transcatheter Cardiovascular Therapeutics Congress, currently ranks behind Portugal (Thomas Bartl, personal communication). Information drawn from registry data is increasingly given international importance with regard to TAVI [16, 17]. The advantages and disadvantages of observational studies as compared with randomized investigations in TAVI are an ongoing issue [16, 17].

Conflict of interest

The authors declare that there are no actual or potential conflicts of interest in relation to this article.

Appendix

Austrian Cardiac Catheter Centers, 2012/2013

1	*Klagenfurt:* Landeskrankenhaus, Innere Medizin II	2004–2005[a]
	Prof. Georg Grimm	
2	*Wien:* Universitätsklinik, Kardiologie, Innere Medizin II	2013[a]
	Prof. Georg Delle Karth, Prof. Thomas Neunteufl	
3	*Linz:* Krankenhaus der Elisabethinen, Innere Medizin	2006[a]
	Dr. Josef Aichinger	
4	*Graz:* Universitätsklinik, Kardiologie, Innere Medizin	2004–2005 + 2013[a]
	Prof. Helmut Brusse, Prof. B. Pieske	
5	*Salzburg:* Invasive Kardiologie Dr. Heyer	2004–2005[a]
	Dr. Günter Heyer	
6	*Wien:* Krankenhaus Hietzing (Lainz), 4.Med. Abteilung mit Kardiologie	2010[a]
	Dr. Michael Brunner, Dr. Johann Pollak	
7	*Bad Schallerbach:* Sonderkrankenanstalt, Rehabilitationszentrum	2006[a]
	Prof. Peter Schmid, Dr. G. Helmreich	
8	*Graz:* LKH Graz-West, Innere Medizin	2004–2005 + 2009[a]
	Dr. W. Weihs, Dr. H.W. Schuchlenz	
9	*Linz:* AKH, Innere Medizin I	2004–2005[a]
	Prof. Franz Leisch – Dr. Clemens Steinwender 2013; Dr. Klaus Kerschner	
10	*Villach:* Innere Medizin	2004–2005[a]
	Dr. Heinz Koller + Dr. H. Krappinger	
11	*Wien:* Krankenhaus Rudolfstiftung, Innere Medizin	2004–2005[a]
	Prof. Franz Weidinger	
12	*Feldkirch:* Landeskrankenhaus, Interventionelle Kardiologie	2004–2005[a]
	Dr. Werner Benzer	
13	*Wien:* Hanusch-Krankenhaus, Innere Medizin	2011[a]
	Dr. Georg Gaul, as of 2012: Dr. Sipötz	
14	*Wien:* Privatklinik Josefstadt, Confraternität, ITC Herzkatheterlabor	2012[a]
	Ms. Bohantsch c/o. Dr. Gerhard Bonner, Prof. Helmut Dietmar Glogar, Prof. Ronald Karnik and Dr. Norbert Muzika	
15	*Schwarzach/St.Veit:* Innere Medizin	2004–2005[a]
	Dr. Hubert Wallner	
16	*Salzburg:* Landeskrankenhaus, Innere Medizin	2004–2005 + 2006[a]
	Dr. Matthias Heigert, as of 2012: Prof. Uta C. Hoppe, until 2010: Prof. Max Pichler	
17	*Bruck an der Mur:* LKH, Medizinische Abteilung	2008[a]
	Dr. Gerald Zenker, Dr. Klaus Kaspar	
18	*Wien:* Wilhelminenspital, Innere Medizin und Kardiologie	2004–2005[a]
	Prof. Kurt Huber	
19	*Linz:* Krankenhaus der Barmherzigen Schwestern, Innere Medizin und Kardiologie	2004–2005[a]
	Prof. P. Siostrzonek	

20	*St.Radegund:* Sonderkrankenanstalt Rehabilitationszentrum	2004–2005[a]
	Dr. Dieter Brandt , until 2008: DDr. Wonisch, Dr. G. Obermayer, as of 2012 Dr. Hödl	
21	*Eisenstadt:* Krankenhaus der Barmherzigen Brüder, Innere Medizin	2004–2005[a]
	Prof. Karl Silberbauer	
22	*Wels:* Klinikum Wels-Grieskirchen, Abteilung für Innere Medizin II mit Kardiologie und Intensivmedizin	2004–2005+2012[a]
	Prof. Bernd Eber	
23	*Krems:* Krankenhaus der Stadt Krems, Innere Medizin	2008[a]
	Dr. G. Kronik	
24	*St.Pölten:* Landeskrankenhaus, Innere Medizin	2008[a]
	Prof. Harald Mayr, Dr. Paul Vock	
25	*Innsbruck:* Universitätsklinik, Innere Medizin, Kardiologie	
	Prof. Otmar Pachinger	
26	*Lienz:* Bezirkskrankenhaus, Interne Abteilung	2009[a]
	Prof. Peter Lechleitner, Dr. Peter Lukasser	
27	*Wien:* SMZ Ost, Donauspital, 1. Medizinische Abteilung	2008[a]
	Prof. Heinrich Weber, as of 2012 Prof. Thomas Stefenelli, Dr. Michael Lanik	
28	*Mistelbach:* Krankenhaus, Innere Medizin	2008[a]
	Dr. Otto Traindl	
29	*Wiener Neustadt:* AKH, II. Interne Abteilung	2010[a]
	Dr. T. Brunner, Dr. C. Rott	
30	*Wien:* Wiener Privatklinik	2013[a]
	Prof. Peter Probs, Chief Assistant Sonja Willim	
31	*Mödling:* Innere Medizin mit Kardiologie	2008[a]
	Dr. F.X. Roithinger	
32	*Wien:* Rudolfinerhaus, Institut für Invasive Kardiologie	2008[a]
	Dr. T. Brunner	
33	*Waidhofen/Ybbs:* Landesklinikum, Innere Medizin	2008+2009[a]
	Prim. Dr. Martin Gattermeier	
34	*Wien:* SMZ-SÜD/ KFJ- Spital, 5.Med.Abt.	2009[a]
	Dr. A. Podczeck-Schweighofer, Prof. G. Christ	
35	*Braunau/Simbach:* KH St. Josef-Braunau/ Herzkatheter Simbach, 1. Interne Abteilung mit Kardiologie und Intensivmedizin	2009, closed in 2012[a]
	Dr. J. Auer	
36	*Hochegg-Grimmenstein:* Sonderkrankenanstalt Rehabilitationszentrum, Herzkatheter-Zentrum	2008, closed in 2011[a]
	Prof. Martin Klicpera	
37	*Ried im Innkreis:* KH der BS, Abt.Kardiologie, Herzkatheter	December 2009, closed in 2011[a]
	Dr. Thomas Winter	
38	*Großgmain:* Sonderkrankenanstalt Rehabilitationszentrum, Herzkatheter-Zentrum	Closed in 2009
39	*Klagenfurt:* Maria Hilf, privates Katheterlabor	Re-initiated in 2012
	Dr. Josef Sykora, ab 2012	

[a]Year of monitoring visit and/or audit by data officer

References

1. Mühlberger V. Entwicklungsstand der Interventionellen Kardiologie in Österreich. Wien Med Wochenschr. 1992;15–16:324–30.
2. Mühlberger V, Probst P, Pachinger O. Statistical analysis of invasive cardiology for Austria in 1992 as an approach to quality assessment. J Interv Cardiol. 1994;7:17–24.
3. Maier W, Windecker S, Lablanche JM, Mühlberger V, Wijns W, Meier B (on behalf of the working group Coronary Circulation of the European Society of Cardiology). The European registry of cardiac catheter interventions 1996. Eur Heart J. 2001;22:373–7.
4. Mühlberger V, Kobel C, Kaltenbach L, Pachinger O. Herzkathetereingriffe in Österreich im Jahr 2010 (mit Audit 2004 bis 2011). J Kardiol. 2012;19:63–71. Langversion 63–76. http://www.kup.at/kup/pdf/9522.pdf.
5. Meier B. Evolution und Zukunftsperspektiven der perkutanen Koronarintervention (PCI). J Kardiol. 2010;17(7–8):273–8.
6. Maeder TM, Kaiser CA, Pedrazzini G, Roffi M, Cook St, Corti R, Wenaweser P, Rickli H. Interventional cardiology in Switzerland during the year 2011. Cardiovascular Medicine 2013 bzw. Personal Communication: Maeder. 2013.
7. Bruckenberger E. Herzbericht 2010 mit Transplantationschirurgie; 23. Bericht. Sektorübergreifende Versorgungsanalyse zur Kardiologie und Herzchirurgie in Deutschland sowie vergleichende Daten zur Kardiologie aus Österreich und der Schweiz. Eigenverlag; 1. Oktober 2011; Hitzackerweg 1a; 30625 Hannover. http://www.bruckenberger.de.
8. Meinerz T. Deutscher Herzbericht 2011. 24. Bericht. Sektorübergreifende Versorgungsanalyse zur Kardiologie und Herzchirurgie in Deutschland. Eigenverlag; Dezember 2012. Deutsche Herzstiftung e.V. Vogtstr. 50, 60322 Frankfurt a. M.
9. Flynn MR, Barrett C, Cosío FG, Gitt AK, Wallentin L, Kearney P, Lonergan M, Shelley E, Simoons ML. The Cardiology Audit and Registration Data Standards (CARDS), European data standards for clinical cardiology practice. Eur Heart J. 2005;26:308–13.
10. Thiele H, Zeymer U, Neumann FJ, et al. Intraaortic balloon support for myocardial infarction with cardiogenic shock. N Engl J Med. 2012;367:1287–96.
11. Shanian DM, Meyer GS, Yeh RW, Fifer MA, Torchiana DF. Percutaneous coronary interventions without on-site cardiac surgical backup. N Engl J Med. 2012;366:1814–23.
12. Jacobs AK, Sharon-Lise TN, Massaro JM, Cutlip DE, Carrozza JP, Marks AD, Murphy N, Romm IK, Biondolillo M, Mauri L. Nonemergency PCI at Hospitals with or without on-site cardiac surgery. N Engl J Med. 2013;368(16):1498–508.
13. Suter M. Der Koch. Zürich: Diogenes Verlag; 2010. S. 277–278.
14. De Bruyne B, Pijls NH, Kalesan B; FAME 2 Trial Investigators. Fractional flow reserve-guided PCI versus medical therapy in stable coronary disease. N Engl J Med. 2012;367:991–1001.
15. Schistek R. Transkutaner Aortenklappenersatz (TAVI). Klinik 6/2012. S. 1.
16. Gilard M; for the FRANCE 2 Investigators. Registry of transcatheter aortic-valve implantation in high-risk patients. N Engl J Med. 2012;366:1705–15.
17. Mauri L. Why we still need randomized trials to compare effectiveness. N Engl J Med. 2012;366:1538–41.