

CARDIAC CATHETERIZATION IN GERMANY

Diffusion and Utilization from 1984 to 1996

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Abstract

Objective: To describe the diffusion of cardiac catheterization technologies and time trends of their use according to setting and geographic region in Germany during a 13-year period. It is hypothesized that the cardiac catheterization technology has matured from an experimental state to a broadly accepted technology.

Methods: Data come from the annual survey of the German Society for Cardiovascular Research. All German cardiac catheterization units are requested to provide data on volume and type of catheterization procedures. Data are available from 1984 to 1996. Number and type of procedure, type of unit, diagnoses, and complications are all recorded. The overall response rate is 90%, on average.

Results: The total number of catheterization units was 324 in 1996, or an average of 3.69 units per 1 million population. In 1996, all of the East German Länder and districts were below average. Utilization of cardiac catheterization procedures increased exponentially during the study period. The number of angiographies rose from about 45,000 in 1984 to more than 450,000 in 1996; the number of angioplasties increased almost by a factor of 50 to 125,000 procedures in 1996. Inverse correlations between the rates per million population of either coronary angiographies or PTCA and mortality rates from ischemic heart disease were observed at the level of the German Länder.

Conclusion: Further studies taking patient characteristics, long-term outcomes, and other factors in account are necessary to clarify the large geographic variations and the negative relationship between utilization rates and coronary heart disease mortality found in this study.

Keywords: Diffusion of innovation, Technology assessment, biomedical, Germany, Coronary disease, Coronary angiography, Angioplasty, transluminal, percutaneous coronary

Coronary angiography and percutaneous transluminal coronary angioplasty (PTCA) have become standard procedures of interventional cardiology with a great potential of benefit for patients with coronary heart disease (CHD).

Diagnostic and therapeutic catheterization procedures of the left heart are being performed in a rapidly increasing number in Germany. Of all cardiac catheterizations in Europe registered by the European Heart Institute in 1995, Germany

took the lead position in terms of both the absolute number of procedures and the rate. This applies to both coronary angiography and PTCA (14).

This paper presents data on the diffusion and utilization of coronary angiography and PTCA in Germany over a time span of 13 years by geographic region, while examining two aspects: diffusion of cardiac catheterization laboratories and utilization of these units. It is hypothesized that cardiac catheterization technology has matured from an experimental state to a broadly accepted technology. Since our data are not patient-based, only trends in laboratory performance can be analyzed. These trends may offer hypotheses for further analyses based on individual patient data.

METHODS

The data of this analysis come from the annual survey of the German Commission for Clinical Cardiology (of the German Society for Cardiovascular Research). Cardiac catheterization laboratories were identified and asked to voluntarily provide data on their volume and type of catheterization procedures, diagnoses, suggested treatments, and complications. Data on complications were disregarded since questions in the survey changed over time, and the data are largely incomplete on this issue. In addition, structural data such as type of provider of a catheterization unit (university hospital, general hospital, ambulatory practice, rehabilitation clinic, specialty clinic), number of laboratories within the units as well as procedural parameters, (e.g., waiting times) were part of the questionnaire. For the purpose of this study, catheterization units are defined as laboratories of either of the abovementioned providers, which may have one or more catheterization labs (5;6). In Germany, ambulatory practices are able to perform cardiac catheterization procedures under the statutory health insurance and are thus one of the providers of cardiac catheterization units.

This survey has been carried out annually since 1984. The East German federal states (Länder) have been included since 1990. On average the response rate has been 90%, including all major laboratories. Thus, the data can be viewed as representative for Germany.

The diffusion data of cardiac catheterization units in Germany between 1984 and 1996 were analyzed by administrative districts (administrative districts of the Länder, so-called *Regierungsbezirke*). Only fully functioning laboratories were included in the calculations. The number of catheterization units were expressed as both rates per 1 million population and rates per 100,000 population over 30 years of age, in order to improve comparability with published data from other countries (4;14).

Utilization data were analyzed for coronary angiographies, PTCAs, proportion of patients with a diagnosis of CHD, and indications for coronary artery bypass graft (CABG) or PTCA. Patients not suffering from CHD, valvular heart disease, or cardiomyopathy were coded as having "other disease." A descriptive analysis of these data focused on the different providers and on comparisons between administrative districts.

Finally, utilization rates of both coronary angiography and PTCA as well as rates of cardiac catheterization units per 1 million population were correlated with mortality rates from ischemic heart disease at the level of the German Länder.¹ This was done by means of calculating the Pearson correlation coefficients. Coronary heart disease mortality rates were calculated for the 9th revision of the International

Classification of Diseases (ICD) codes 410 (acute myocardial infarction) and 414 (other types of ischemic heart disease), which account for 98.8% of all patients who died from ischemic heart disease in Germany in 1996.

RESULTS

Diffusion of Cardiac Catheterization Units in Germany Since 1984

Between 1984 and 1996, the number of cardiac catheterization units for adult patients increased about sixfold. Table 1 shows the numbers by type of laboratory for each year. The total number of catheterization units was 324 in 1996, an average of 3.69 units per 1 million population (range, 0.59–10.42) or 0.61 (range, 0.09–1.65) catheterization units per 100,000 population older than 30 years of age. In 1996 all of the East German Länder and Regierungsbezirke, respectively, were below the average, whereas less than half of the West German regions fell in that category (Table 2).

The average number of labs per catheterization unit ranges between 1.1 for general hospitals and 2 for university hospitals and specialty clinics.

Utilization of Cardiac Catheterization Procedures in Germany

Utilization of cardiac catheterization procedures increased exponentially during the study period. The number of angiographies rose from about 45,000 in 1984 to more than 450,000 in 1996. The number of angioplasties increased almost by a factor of 50 to 125,000 procedures in 1996.

The contribution of the different types of laboratories to the total number of procedures has changed considerably over time. In 1984, 44% of all angiographies were performed in university clinics, 37% in general hospitals, and only 2% in ambulatory practices. In 1996, 50% of all angiographies were performed in general hospitals, only 19% in university hospitals, and 18% in ambulatory practices. The contribution of rehabilitation and specialty clinics remained relatively stable during that time.

These changes were even more marked for angioplasties. University hospitals performed 74% of all angioplasties in 1984, but only 25% in 1996. In the meantime, the contribution of general hospitals increased from 14% to 42% and the contribution of ambulatory practices from 0 to 18% in 1996. As with angiographies, the contribution of rehabilitation clinics and specialty clinics was stable at about 15%.

If analyzed according to administrative districts, the utilization pattern for 1996 was consistent with the previously mentioned geographic inequalities, with 8 of 9 East German areas ranging below the average, in comparison to 13 of 31 West German areas.

Utilization of Cardiac Catheterization Procedures According to Provider

Utilization data were analyzed according to provider, since the rapid change in the contribution rates over time also suggested changing utilization patterns of catheterization procedures. An increase over time can be observed for all providers. The workload per lab reached a plateau; thus, an increase in utilization was due to an increase in number of labs per unit. In contrast, the percentage of patients with a diagnosis of CHD remained stable at about 70% for all providers. Of interest is the declining percentage of CHD diagnoses in rehabilitation clinics and the increase in the category of "other diagnoses" for the same time period. The category

Table 1. Number of Cardiac Catheterization Units by Provider and by Year

Year	Total no. of units	Total no. of labs	Provider (N)				
			General hospital	University hospital	Specialty clinic	Ambulatory practice	Rehabilitation clinic
1984	65	^a	33	22	5	1	4
1985	77	^a	35	25	5	1	11
1986	95	^a	47	29	7	2	10
1987	116	145	65	27	7	4	13
1988	127	148	73	29	8	5	12
1989	137	159	77	32	10	5	13
1990 ^b	155	180	87	35	12	6	15
1991	174	217	99	37	12	11	15
1992	180	228	102	37	12	14	15
1993	193	258	116	36	14	14	13
1994	285	351	165	40	15	49	16
1995	301	370	174	41	15	54	17
1996	324	393	183	42	16	67	16

^a Number could not be calculated because of more than 10% missing values.^b East German Länder included since 1990.

of “other diagnoses” tends to be higher in ambulatory practices than in other types of laboratories, perhaps reflecting the lower prevalence of patients with CHD in the ambulatory setting. The sum of patients with the diagnosis of CHD and with “other diagnoses” is below 100 because the remainder falls into the category of valvular heart disease (data not shown). There were inverse trends in the percentages of patients considered for either PTCA or CABG after angiography, but the total percentage of patients considered for either procedure remained constant at about 50%.

Correlation Between Utilization Rates and Mortality from Ischemic Heart Disease

Statistically significant inverse correlations between the rates per million population of either coronary angiographies or PTCAs and mortality rates from ischemic heart disease were found at the level of the German Länder. The correlation coefficients were $r = -0.6$ ($p = .013$) and $r = -0.58$ ($p = .017$) for mortality with angiographies and PTCAs, respectively (Figure 1). In addition, a significant correlation was found for the number of cardiac catheterization units per 1 million population and mortality from coronary heart disease ($r = -0.57$, $p = .02$) (Figure 2). The correlation coefficients explain 36% (angiography), 34% (PTCA), and 33% (units per 1 million population) of the variance.

DISCUSSION

Data on cardiac catheterization procedures have not yet been presented in a longitudinal analysis for Germany. This study attempts to depict trends in diffusion and utilization over a period of 13 years. Since the available data are not patient-based, it is not possible to draw any conclusions about the appropriateness of indications or (long-term) patient outcomes. Because of the highly aggregated nature of the data, no attempt was made to analyze the trends below the descriptive level. However, the data may serve as a basis for further studies that match patient data with other types of data.

The diffusion of the cardiac catheterization technology in Germany follows a pattern that can be observed for other expensive health technologies as well (1;9). Initially, new technologies are used in academic centers, then a period of adoption leads to diffusion to the “periphery,” that is, uptake by general hospitals and ambulatory practices. This pattern is well reflected in data for both diffusion and utilization of cardiac catheterization procedures.

During the past few years, coronary angiography and, increasingly, angioplasty have matured from essentially university-based procedures to routinely performed procedures in cardiology. The contribution of the different providers to the total number of performed angiographic and angioplastic procedures has changed over time. Initially, university hospitals performed the major part of all procedures. Although the number of procedures performed in university hospitals increased during the time period under consideration, most of the procedures are now performed in general hospitals. In 1996 the majority of cardiac catheterization units were run by general hospitals (56% of all units), 13% of all units were in university hospitals, and a rapidly increasing proportion, currently 20%, in ambulatory (private) practices. The increasing competition between general hospitals and private ambulatory practices could possibly lead to an expansion of indications for coronary interventions. This can already be seen in other countries (12). However, a small

but increasing proportion of cardiologists in private practice perform catheterization procedures in hospitals (data not shown). This could lead to bias in future analyses of the contribution rates of the different laboratory types to the total number of procedures performed.

The workload of the individual catheterization labs has remained relatively stable since about 1991, which may be a result of a needs-based approach to the installation of new devices; increasing demand is met by increasing the number of catheterization labs, not by increasing the workload of the labs (8).

Despite a rapid increase in the number of catheterization units during the past few years, the distribution according to region remains unequal, with all East German Länder falling below the (German) average. This is reflected in the utilization of catheterization procedures according to geographic region. With the exception of Leipzig, all East German regions appear underserved when compared with West German regions. For some administrative districts, a plausible explanation for their utilization rates could be found. For example, in Hamburg the number of catheterization units as well as the utilization rates are well above the average, which could be due to the attraction of patients from the neighboring regions of Schleswig-Holstein and Lüneburg (both are well below the average). For the regions Tübingen, Freiburg, Karlsruhe, and Stuttgart (the four administrative districts of Baden-Württemberg), previous efforts to restrict the installation of high-cost medical devices could explain the average performance rates. This may also be true for Niedersachsen (with its administrative districts Weser-Ems, Lüneburg, Hannover, and Braunschweig) (8).

A possible expansion of the indication spectrum for coronary angiographies and PTCAs should result in a growing rate of patients not diagnosed with coronary heart disease (category "other diagnoses") and decreasing rates of patients referred to surgery. Similarly, rates for referral to PTCA should rise. These effects could be assumed at least for patients in rehabilitation clinics, which show a marked decline in the proportion of patients with the diagnosis of coronary heart disease and an increase of the residual category of "other diagnoses" at the same time. However, whether this might be due to chance or a systematic trend cannot be decided with our data. With regard to the growing financial pressure facing German hospitals, especially rehabilitation hospitals, the downward trend of CHD diagnoses could be explained by a broadening of indications for angiography in order to compensate for the loss of income from other services. Decreasing rates of patients referred to surgery and increasing rates referred to PTCA occur throughout the different providers. However, the absolute number of patients referred to either PTCA or CABG is increasing due to the increasing numbers of angiographies.

In comparison to other European countries, Germany has the highest utilization rates, together with Belgium, Switzerland, Austria, and the Netherlands (14). Although the annual increase in utilization rates is considerable, it reveals some important trends. One trend is the increasing number of patients undergoing angioplasty directly after coronary angiography ("immediate" or "prima vista" PTCA). Recently published data of a German PTCA registry show that the proportion of immediate PTCA interventions during angiography increased between 1992 and 1994 from 23% to 40% (15). Data for Austria show an immediate PTCA rate of 48% for 1994 (10) and 61% for 1997.² The rate of immediate PTCA in eight selected German ambulatory practices in 1996 was 15% (13).

Another important development is the growing use of coronary stents as an elective or emergency procedure. Recent data from a U.S. registry indicate a higher

Table 2. Cardiac Catheterization Units and Utilization Rates of Angiographies and PTCA's According to the German Länder and Regierungsbezirke in 1996

<i>Land/Regierungsbezirk</i>	Catheterization units				Angiography rate per 1 million population >30 yrs	PTCA rate per 1 million population	Angiography rate per 100,000 population >30 yrs	PTCA rate per 100,000 population >30 yrs
	No. of units	Per 1 million population	Per 100,000 population >30 yrs	Angiography rate per 1 million population				
<i>Baden-Württemberg</i>	W ^a							
Stuttgart	16	3.88	0.61	3674	721	581	114	
Karlsruhe	8	4.14	0.66	4747	1540	737	239	
Freiburg	8	3.03	0.47	6095	1658	971	264	
Tübingen	8	3.83	0.61	5858	2036	956	332	
<i>Bayern</i>	W							
Oberbayern	48	4.64	0.76					
Niederbayern	21	4.00	0.63	7723	2288	1188	352	
Oberpfalz	6	5.28	0.81	4557	497	733	80	
Oberfranken	3	2.85	0.84	3766	1004	602	161	
Mittelfranken	3	2.70	0.42	3482	488	542	76	
Unterfranken	6	3.60	0.56	6539	1555	1011	240	
Schwaben	6	4.55	0.73	8365	2088	1333	333	
<i>Berlin</i>	E/W							
Brandenburg	15	1.74	0.28	1653	315	264	50	
Bremen	6	4.32	0.66	6715	2300	1027	352	
Hamburg	E ^a	2.36	0.37	2536	509	396	79	
Hessen	W	2.94	0.44	7357	2588	1104	388	
Darmstadt	W	4.68	0.7	9621	3900	1443	585	
Giessen	12	4.83	0.74	6746	2958	1022	448	
Kassel	11	3.26	0.49	11630	3287	1846	522	
<i>Mecklenburg-Vorp.</i>	E	10.42	1.65	7875	4657	1220	722	
Niedersachsen	6	4.73	0.73	5178	1305	830	209	
Braunschweig	6	3.29	0.53					
Hannover	32	4.11	0.64	7596	1612	1178	250	
Lüneburg	7	4.12	0.64	4045	1142	614	173	
Weser-Ems	7	3.27	0.5	3311	429	514	67	
	11	4.37	0.68	5081	865	833	142	
		4.66	0.77					

(Continued)

Table 2. (Continued)

<i>Land/Regierungsbezirk</i>	No. of units	Catheterization units			Angiography rate per 1 million population	PTCA rate per 1 million population	Angiography rate per 100,000 population >30 yrs	PTCA rate per 100,000 population >30 yrs
		Per 1 million population	Per 100,000 population >30 yrs	Per 100,000 population >30 yrs				
<i>Nordrhein-Westfalen</i>	91	5.09	0.79	8026	2222	1211	335	
Düsseldorf	34	6.43	0.97	4968	1251	766	193	
Köln	14	3.34	0.52	4297	932	692	150	
Münster	11	4.27	0.69	7964	1553	1268	247	
Detmold	8	3.97	0.63	6151	1482	952	229	
Arnsberg	24	6.27	0.97					
<i>Rheinland-Pfalz</i>	10	2.51	0.39					
Koblenz	5	3.36	0.52	3127	352	484	55	
Trier	1	1.98	0.31	5948	2384	936	375	
Rheinh.-Pfalz	4	2.02	0.31	5289	1549	814	238	
Saarland	4	3.69	0.55	7608	2922	1141	438	
<i>Sachsen</i>	7	1.53	0.23					
Chemnitz	1	0.59	0.09	1025	247	153	37	
Dresden	3	1.70	0.26	5087	1179	784	182	
Leipzig	3	2.70	0.41	9355	2793	1414	422	
<i>Sachsen-Anhalt</i>	7	2.56	0.39					
Dessau	1	1.74	0.27	3399	811	517	123	
Halle	3	3.30	0.5	4197	915	640	140	
Magdeburg	3	2.39	0.37	3199	178	494	28	
<i>Schleswig-Holstein</i>	12	4.40	0.68	3250	727	501	112	
<i>Thüringen</i>	7	2.80	0.43	2896	526	448	81	
	324 ^b	3.96 ^c	0.61 ^c	5523 ^c	1538 ^c	857 ^c	239 ^c	

^a W denotes West German districts; E denotes East German districts.

^b Total.

^c Average.

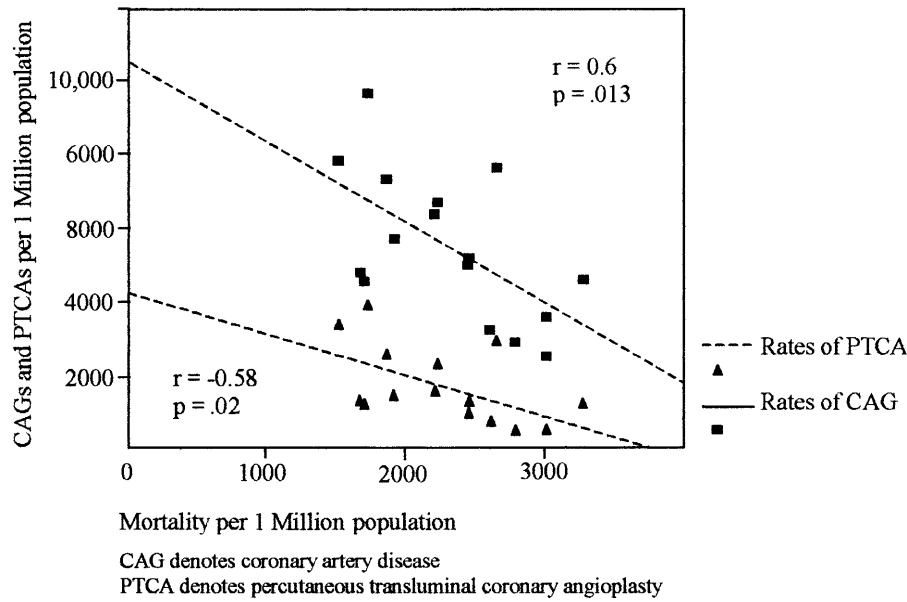


Figure 1. Correlation between cardiac interventions and mortality from cardiovascular heart disease.

complication rate and lower procedural success rate for unplanned stenting (3). Since these trends cannot be investigated from the current database, it would be highly desirable for future analysis to link utilization data at the institutional level with patient-based data in order to compare indications and appropriateness of coronary interventions.

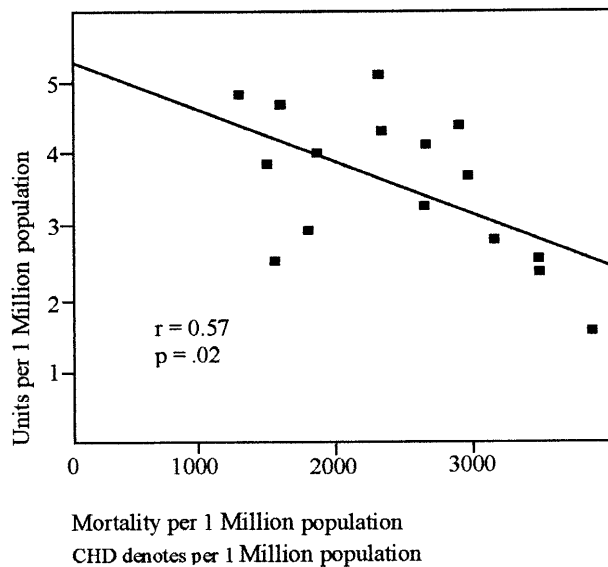


Figure 2. Correlation between mortality from cardiovascular heart disease and cardiac catheterization units.

A somewhat surprising result of this study is an inverse correlation between coronary intervention rates and mortality rates from CHD. In other words, the more cardiac interventions are performed, the lower the observed mortality rate from CHD. However, this correlation should be interpreted carefully. Since the data are highly aggregated and neither risk adjustments for patients nor adjustments for institution characteristics are possible, explanatory analyses such as multiple regression methods are not feasible.

Recently published data from the GUSTO trial indicate that patients with acute myocardial infarction, who are treated more frequently in the United States, showed a lower mortality rate after 1 year than did patients treated less aggressively in other countries. The authors, however, could not decide whether selection bias or the benefits of the more aggressive therapy were responsible for the outcome (7). Data from the BARI trial (11) also showed a correlation of somehow vaguely defined "patterns of medical care" with functional status of patients after PTCA or bypass surgery. Patients from the United States showed a better functional status than their counterparts in Canada, suggesting differences in the medical management of the patients. Other explanations were also deemed possible, however.

A recent German study focused on the regional variations in CHD mortality rates in Germany. On the basis of the available data, the authors concluded that differences of acute medical care, risk factors, lifestyle, and socioeconomic circumstances may all contribute to this phenomenon (16).

One possible explanation of the inverse correlation we found is that coronary angioplasty could extend the duration of symptom-free survival from CHD and thus postpone the need for bypass surgery. The combination of this sequential approach could contribute to an increased life expectancy. This assumption is supported by data on cardiac surgery in Germany. The rate of heart surgery per 100,000 population aged between 70 and 80 has increased from 1990 to 1996 from 95 to 404 (2). This is compatible with data for the United States showing an increase in life expectancy from either CABG or PTCA of up to 7 months for single-vessel disease to up to 14 months for triple-vessel disease of the coronary arteries (17).

Since most deaths due to acute myocardial infarction occur before hospital admission, the density of acute care facilities could also explain in part the observed correlation.

A limitation of this study is the lack of data on patient migration to cardiac catheterization units that provide for surrounding rural areas, which may have resulted in a bias toward overestimation of geographic variations. This could be the case for the cities of Hamburg (providing services for parts of Niedersachsen and Schleswig-Holstein), Bremen (Niedersachsen), and Berlin (Brandenburg).

CONCLUSION

Further studies taking patient characteristics, long-term outcomes, and other factors in account are necessary to clarify the large geographic variations and the negative relationship between utilization rates and coronary heart disease mortality found in this study.

NOTES

¹ Source: Federal Bureau of Statistics, personal communication.

² Source: <http://gin.uibk.ac.at/iik/visitors/index2.htm>, July 8, 1998.

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