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Reperfusion therapy for ST elevation acute myocardial infarction in Europe: description of the current situation in 30 countries

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Aims Patient access to reperfusion therapy and the use of primary percutaneous coronary intervention (p-PCI) or thrombolysis (TL) varies considerably between European countries. The aim of this study was to obtain a realistic contemporary picture of how patients with ST elevation myocardial infarction (STEMI) are treated in different European countries.

Methods and results The chairpersons of the national working groups/societies of interventional cardiology in European countries and selected experts known to be involved in the national registries joined the writing group upon invitation. Data were collected about the country and any existing national STEMI or PCI registries, about STEMI epidemiology, and treatment in each given country and about PCI and p-PCI centres and procedures in each country. Results from the national and/or regional registries in 30 countries were included in this analysis. The annual incidence of hospital admission for any acute myocardial infarction (AMI) varied between 90–312/100 thousand/year, the incidence of STEMI alone ranging from 44 to 142. Primary PCI was the dominant reperfusion strategy in 16 countries and TL in 8 countries. The use of a p-PCI strategy varied between 5 and 92% (of all STEMI patients) and the use of TL between 0 and 55%. Any reperfusion treatment (p-PCI or TL) was used in 37–93% of STEMI patients. Significantly less reperfusion therapy was used in those countries where TL was the dominant strategy. The number of p-PCI procedures per million per year varied among countries between 20 and 970. The mean population served by a single p-PCI centre varied between 0.3 and 7.4 million inhabitants. In those countries offering p-PCI services to the majority of their STEMI patients, this population varied between 0.3 and 1.1 million per centre. In-hospital mortality of all consecutive STEMI patients varied between 4.2 and 13.5%, for patients treated by TL between 3.5 and 14% and for patients treated by p-PCI between 2.7 and 8%. The time reported from symptom onset to the first medical contact (FMC) varied between 60 and 210 min, FMC-needle time for TL between 30 and 110 min, and FMC-balloon time for p-PCI between 60 and 177 min.

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Conclusion Most North, West, and Central European countries used p-PCI for the majority of their STEMI patients. The lack of organized p-PCI networks was associated with fewer patients overall receiving some form of reperfusion therapy.

Keywords Acute myocardial infarction • Reperfusion therapy • Thrombolysis • Primary angioplasty • Europe • Mortality • Incidence

Introduction

Primary percutaneous coronary intervention (PCI) and thrombolysis (TL) represent two alternative reperfusion strategies for ST elevation acute myocardial infarction (STEMI). In common, TL is considered to be more widely available and can be started faster than primary PCI. In many randomized clinical trials,[1–6] primary PCI has been shown to be superior to TL in reducing mortality, re-infarction, and stroke. This benefit is related to a much higher early mechanical reperfusion rate (ca. 90%) compared with pharmacological reperfusion rate (ca. 50%), to the ability of simultaneously treating the underlying stenosis and finally to the lower risk of severe bleeding. The most recent European Society of Cardiology (ESC) guidelines[7,8] recommend primary PCI as the preferred treatment whenever it is available within 90–120 min of the first medical contact (FMC). The aim of this project was to analyse the use of reperfusion treatments across Europe at the time when these new ESC guidelines were published.

Methods

The European Association for Percutaneous Cardiovascular Interventions (EAPCI) invited the chairpersons of the national working groups/societies of interventional cardiology in all 51 European Society of Cardiology (ESC) countries and selected experts known to be involved in the national registries of STEMI to join this project. Positive replies were received from 30 countries. Data were collected about the country and any existing national STEMI or PCI registries, about STEMI hospital admissions and treatment in each given country, and about PCI and primary PCI centres and procedures in each country. Specifically, each participating national working group (or society) provided the precise number of all existing PCI hospitals in the given country and how many of them offer non-stop (24/7) primary PCI services. Primary PCI centre (24/7) was defined as PCI hospital not using TL for the treatment of STEMI patients, in other words hospital performing primary PCI in all STEMI patients, 24 h/day and 7 days/week.

Results from 30 European countries were included in this analysis (*Tables 1* and *2*). These data reflect the situation in years 2007–2008 for most countries, but in 2006 or 2005 for a few, in whom the most recent data were not available.

Those national data already published are listed in the references section[9–27] and the names of ongoing registries and/or surveys are listed in the appendix and more details in *Table 1*.

Besides obtaining the numbers from the individual countries, the contributors were also asked to describe subjectively, what they consider to be the main barriers for better p-PCI implementation and to comment on the possible influence of hospital/staff reimbursement on the local situation.

Statistical analysis

Data are presented in the descriptive format as we received them from each individual country (see appendix for the list of contributors). The SPSS 12.0 statistical package was used to fit the linear regression lines.

Results

Annual incidence of hospital admission for acute myocardial infarction

The annual incidence of hospital admission for *any* acute myocardial infarction (AMI) varied between 90–312/100 000 inhabitants/year and the incidence of hospital admissions for *STEMI* alone between 44–142/100 000 inhabitants/year (*Table 2*).

Reperfusion strategy use

Primary PCI is the dominant reperfusion strategy in 16 countries and TL in 8 countries. From five countries (Denmark, Estonia, Lithuania, Norway, and Spain), only information about primary PCI (and not about TL) was available. The use of a p-PCI strategy varies between 5 and 92% (of all STEMI patients) and the use of TL between 0 and 55%. Any reperfusion treatment (p-PCI or TL) is used in 37–93% of STEMI patients (*Figure 1*). Overall, in those countries using TL as the dominant strategy, the overall population receiving some form of reperfusion therapy is lower (only 55% patients are treated, although this varied considerably from country to country).

The population need for primary PCI services

The number of primary PCI procedures per 100 000 inhabitants per year (*Table 3*; *Figure 2*) ranged from 2 to 97. The mean population served by a single p-PCI centre (*Table 4*) varies between 0.3 and 7.4 million inhabitants. In those countries offering p-PCI services to the majority of their STEMI patients, this population varies between 0.3 and 1.1 million per centre. There was a weak correlation between numbers of PCI procedures and the gross domestic product per capita (*Figure 3*; *Table 3*).

Mortality

The in-hospital mortality of all consecutive STEMI patients (*Table 5*) varies between 4.2 and 13.5%, for patients treated by TL between 3.5 and 14%, and for patients treated by primary PCI between 2.7 and 8%.

Time delays

The time from symptom onset to the FMC (defined as the time of diagnostic ECG) ranged from 60 to 210 min, FMC-needle time for TL between 30 and 110 min and FMC-balloon time for p-PCI between 60 and 177 min. These FMC-balloon times are given for all primary PCI procedures, irrespective of whether the patient

Table 1 National registries and other sources of the countries' data for this study

Country	Year	STEMI registry (name)	PCI registry (name)	Other registry or survey (name)	Expert estimate only	Completeness of STEMI capturing per period and region
Austria	2005–07	VIENNA STEMI registry[34]	Austrian Heart Catheter Registry[36]	Austrian Acute PCI Registry[37]	–	100% in Vienna region, ca. 50% for Austria
Belgium	2008	Belgian STEMI registry	Belgian Working Group Interventional Cardiology registry			50%
Bulgaria	2007	National Health Insurance Fund	National Health Insurance Fund, Bulgarian WG Interventional Cardiology	–	–	100%
Croatia	2005–08	Croatian Cardiac Society, WG for Acute Coronary Syndromes	Croatian Cardiac Society; Hospital PCI Registries	Zagreb AMI Registry; Croatian Institute of Public Health		90% for STEMI; 100% for PCI
Czech Republic	2005–07	CZECH registry (all ACS)[19]	NRKI registry	–	–	100% for all ACS in the CZECH registry
Denmark	2007	None	Danish Heart Registry	–	For AMI not undergoing PCI	100% for p-PCI
Estonia	2008	Estonian Myocardial Infarction Registry, WG on Acute Coronary Syndromes	–	–	–	100%
France	2005	FAST-MI[33]	FAR	–	–	60% of ICUs
Finland	2006	–	–	Registry of Cardiovascular Diseases, National Institute for Health and Welfare[18]	–	ca. 90% for all AMI
Germany	2007–08	German Myocardial infarction registry[46]	–	Herzbericht 2007[47]	–	25%
Greece	2006	HELIOS[14,16]	–	Hellenic Study of AMI[15]	–	100%
Hungary	2004–08	National Health Insurance Database	Registry of the Working Group of Interventional Cardiology	PCI Network in the Middle-Hungarian region (Budapest)	–	100% for all
Italy	2006–08	VENERE,[41] In-ACS (2007); BLITZ 3 (2008)	GISE Registry (GISE=Italian Society of Interventional Cardiology)	Istituto Superiore di Sanità (ISS)	–	100% in Veneto Region; p-PCI 100% in GISE (all Italy); 80% in BLITZ 3
Israel	2006	ACSIS	–	–	–	100%
Latvia	2008	Latvian registry of acute coronary syndromes	Latvian registry of acute coronary syndromes	–	–	100%
Lithuania	2007–08	–	Lithuanian PCI registry	–	Yes for AMIs without PCI	100% for p-PCI only
F.Y.R. Macedonia	2007–08	–	Hospital based registries in all existing PCI centres	–	–	95% in Skopje, ca. 80% for Macedonia
The Netherlands	2008	–	Dutch National PCI Registry (BHN)	–	–	–
Norway	2007	–	PCI-hospital based registries	–	For patients not treated by PCI	Not known (PCI data only)

Continued

Table 1 *Continued*

Country	Year	STEMI registry (name)	PCI registry (name)	Other registry or survey (name)	Expert estimate only	Completeness of STEMI capturing per period and region
Poland	2004–07	PL-ASC Registry	PCI registry of the WG on Cardiovascular Interventions of the Polish Cardiac Society		–	100%
Portugal	2008	National ACS Registry 2002,[43] updated 2009[44]	–	–	–	N.A.
Romania	2007–08	RO-STEMI	–	–	–	100%
Serbia	2007	National Institute for Health	Working group on interventional cardiology[42]			100%
Slovakia	2007	SLOVAKS registry	Registry of the Working Group Interventional Cardiology (Slovak Society of Cardiology)	–	–	46% of all STEMI and 100% of p-PCI in Slovakia
Slovenia	2007	National survey	National survey	–	–	100%
Spain	2007	–	Registro Español de Hemodinámica y Cardiología Intervencionista[45]	–	Yes for AMIs without PCI	N.A.
Sweden	2007	RIKS-HIA	SCAAR	–	–	100%
Switzerland	2007	AMIS Plus (STEMI/NSTEMI/UA registry[48–50])	Swiss PCI survey[51]	–	–	100% for p-PCI, 43% for STEMIs
Turkey	2007	TUMAR registry	–	–	Yes, partly	N.A.
UK	2005–08	Myocardial Ischaemia National Audit Project (MINAP)[38]	British Cardiovascular Intervention Society (BCIS)[39] and Central Cardiac Audit database (CCAD)[40]	–	–	100%

Table 2 Population data and acute myocardial infarction annual incidence

Country	Country population (www.populationmondiale.com)	Hospitalized STEMI/year	STEMI/100 thousand/year	Hospitalized AMI (any)	AMI/100 thousand/year
Austria	8 199 783	7800	95	16 000	195
Belgium	10 584 534	7000	66	12 000	114
Bulgaria	7 640 238	8726	114	11 285	148
Croatia	4 493 312	3600	82	N.A.	N.A.
Czech Republic	10 228 744	6761	66	20 048	196
Denmark	5 468 120	N.A.	N.A.	N.A.	N.A.
Estonia	1 315 912	1751	133	3502	266
France	62 448 977	35 000	55	65 000	105
Finland	5 300 484	4674	88	16 446	310
Germany	82 217 837	100 000	121	208 000	250
Greece	10 706 290	11 780	110	19 853	185
Hungary	9 956 108	8900	89	18 500	186
Italy	58 147 733	67 500	116	147.500	254
Israel	7 337 000	5500	75	10 000	136
Latvia	2 270 894	1437	63	N.A.	N.A.
Lithuania	3 575 439	3000	84	N.A.	N.A.
F.Y.R. Macedonia	2 049 613	1765	86	N.A.	N.A.
The Netherlands	16 405 399	N.A.	N.A.	N.A.	N.A.
Norway	4 703 779	3900	83	12 650	276
Poland	38 518 241	50 000	130	90 000	234
Portugal	10 642 836	11 104	104	N.A.	N.A.
Romania	22 276 056	10 000	45	20 000	90
Serbia	7 400 000	6079	82	8655	117
Slovakia	5 447 522	3635	67	7635	140
Slovenia	2 009 245	1210	60	N.A.	N.A.
Spain	45 116 894	40 000	89	120 000	266
Sweden	9 031 088	6000	66	21 000	232
Switzerland	7 593 494	N.A.	N.A.	11 337	149
Turkey	70 586 256	100 000	142	220 000	312
UK	60 776 238	27 000	44	105 000	173

STEMI, ST elevation acute myocardial infarction; AMI, acute myocardial infarction, N.A., not available.

underwent interhospital transfer or was directly admitted to the PCI hospital (*Table 6*; *Figures 4* and *5*).

STEMI initial presentation

Only approximately half of the patients arrive at the hospital via an EMS ambulance. This proportion varies considerably between countries: from 17% (Greece) to 85% (UK) (*Figure 6*).

Discussion

Geographic differences, heterogenity of care

Primary PCI appears to be now the dominant treatment of STEMI in the majority of countries: Scandinavia (Norway, Denmark, Sweden, and Finland), Central Europe (Czech Republic, Slovenia, Poland, Hungary, Austria, and Croatia), West Europe (Germany, Belgium, France, Switzerland, and the Netherlands), Italy, and Israel. Several countries have the infrastructure available, but do not use it sufficiently to treat most of their AMI patients—this holds true especially for the South Europe (Greece, Bulgaria, Portugal, Spain, and Turkey) and for the UK and Slovakia (however, national programs for p-PCI implementation have already started in these latter two countries). The described 'North-South gradient' in primary PCI services is typically seen in Italy: the Northern part of Italy has p-PCI rates similar to Central or West Europe, while the Southern part of Italy has rates similar to Greece or Turkey. Unfortunately, no or few data have been obtained from Ireland, Iceland, East Europe (Belarus, Ukraina, Russia, Moldova, Bosnia i Herzegovina, FYROM, Albania, and Georgia) and from the Mediterranean non-European countries (ESC members).

The heterogeneity of care is known from international registries—e.g. the GRACE registry showed that the care-seeking

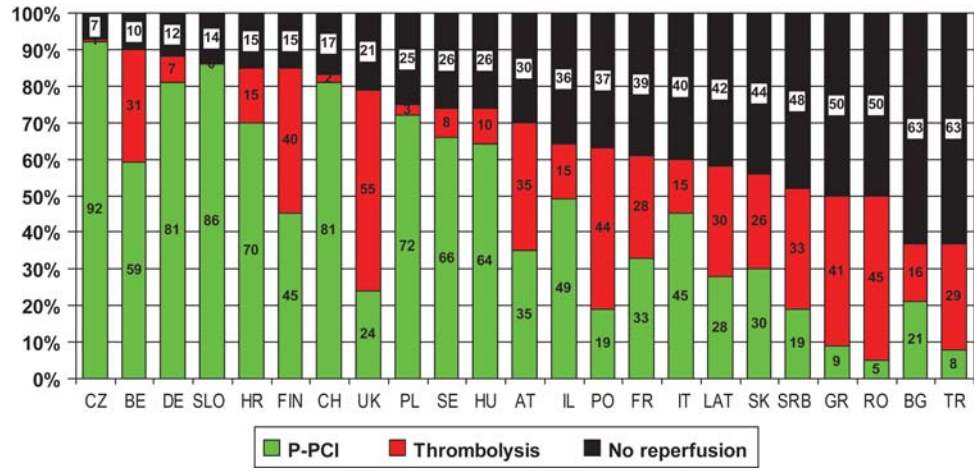

Figure 1 Hospitalized STEMI treatment in Europe (data from national registries or surveys). 100%, all hospitalized STEMI patients in each given country; green colour, STEMI patients treated by primary PCI; red colour, STEMI patients treated by thrombolysis; black colour, STEMI patients not treated with any reperfusion. Countries abbreviations: CZ, Czech Republic; SLO, Slovenia; DE, Germany; CH, Switzerland; PL, Poland; HR, Croatia; SE, Sweden; HU, Hungary; BE, Belgium; IL, Israel; IT, Italy; FIN, Finland; AT, Austria; FR, France; SK, Slovakia; LAT, Latvia; UK, United Kingdom; BG, Bulgaria; PO, Portugal; SRB, Serbia; GR, Greece; TR, Turkey; RO, Romania.

behaviour in patients with acute coronary disease differs among countries or continents.[28]

Annual incidence of the hospital admissions for acute myocardial infarction

The annual incidence of hospital admission for *any* AMI varied considerably, as was the case for the incidence of *STEMI* alone. Those countries with the most precise data (e.g. covering 100% of the population either in the whole country or in selected regions/counties—see *Table 1*) reported the incidence close to the overall mean numbers (ca. 1900 for all AMIs and ca. 800 for STEMIs). In other words, the annual incidence of ca. 1900 hospital admissions for any AMI per year per million population seems to be typical for the European population. This can be used for planning infrastructure because most of these patients will need coronary angiography and subsequent PCI or CABG during their hospital stay.

Reperfusion strategy use

It is of note that primary PCI is already today the leading reperfusion strategy in most European countries. Several countries can serve as evidence that p-PCI may be able to be offered to as many as 70–90% of all STEMI patients in the whole country. An increased use of primary PCI as the preferred reperfusion therapy is identified by this data when compared with the second Euro Heart Survey on Acute Coronary Syndromes (EHS-ACS-II).[29] Results of our study challenge the traditional opinion that TL is the strategy more suitable for widespread application. In some countries, the opposite appears to be true: reperfusion as a whole is offered to less of the STEMI population in those countries using TL as the dominant strategy. This may be related to the many contraindications for thrombolytic therapy and also to the fear of using TL in patients over 75 years of age, who present a significant proportion of all STEMI patients today (e.g. 31% of all hospitalized AMI patients in the Netherlands[30]). Thus p-PCI, despite its logistic complexity, appears to offer broader population reach in some countries.

The population need for primary PCI services

The number of primary PCI procedures per million per year in these countries, covering their population needs, varies between ca. 600 and 900 per million. In these countries, one PCI centre is serving a population of ca. 0.3–0.8 million per centre. These numbers might serve as a reference for planning the infrastructure.

Mortality

The data on mortality between countries cannot be directly compared due to the different methodology of the national registries or surveys. The Czech Republic can serve as an example of these methodological limitations: the in-hospital mortality after p-PCI in the national PCI registry reported by the cardiologists was 3.5%, while after matching the data with the national deaths registry this number rose to 6.7%. This can be explained by the fact that cardiologists are frequently entering the registry data immediately after the procedure, when the patient is subsequently moved from the interventional cardiology unit to another unit (long-term facility, local community hospital, cardiac surgery, long-term rehabilitation unit, etc.) and thus they do not reflect the true (total) hospital outcome.

As with all registries, these data must be interpreted with great caution. The demographic features of patients treated by p-PCI may well be different from those treated by TL. In the National

Table 3 Percutaneous coronary interventions (PCI) per one million inhabitants compared with gross domestic product (GDP) per capital (in US dollars, according to the UN statistics for 2007, http://unstats.un.org/unsd/demographic/products/socind/inc-eco.htm)

Country	All PCIs/year	All PCIs/million	Primary PCIs/year (% of all PCIs)	Primary PCIs/million	GDP per capita (US$)
Austria	19 342	2358	3500 (18%)	426	44 652
Belgium	22 000	2079	3300 (15%)	312	43 469
Bulgaria	6000	785	1801 (30%)	236	5177
Croatia	4000	890	1150 (22%)	255	11 256
Czech Republic	21 531	2105	6720 (31%)	657	16 880
Denmark	10 500	1920	2691 (26%)	481	57 256
Estonia	2471	1878	485 (20%)	369	15 932
France	120 000	1921	14 400 (12%)	231	40 089
Finland	8894	1678	826 (9%)	156	46 370
Germany	299 600	3660	60 000 (20%)	730	40 162
Greece	19 311	1804	1022 (5%)	95	28 111
Hungary	18 500	1858	5700 (31%)	573	13 777
Italy	128 428	2161	22 421 (17%)	376	35 585
Israel	20 000	2726	3500 (17%)	477	23 382
Latvia	5956	2624	410 (7%)	181	11 930
Lithuania	4143	1159	1485 (36%)	415	11 307
F.Y.R. Macedonia	2516	1227	981 (39%)	478	3703
The Netherlands	36 367	2217	11 201 (31%)	683	46 669
Norway	11 890	2530	2632 (22%)	560	82 464
Poland	75 024	1948	26 457 (35%)	687	11 007
Portugal	9873	919	1902 (19%)	179	20 990
Romania	6560	294	450 (7%)	20	7523
Serbia	6395	864	1161 (18%)	157	5382
Slovakia	5730	1061	1924 (34%)	356	13 701
Slovenia	3336	1661	1043 (31%)	519	22 936
Spain	60 457	1340	11 322 (19%)	251	32 450
Sweden	19 000	2103	5421 (29%)	600	49 873
Switzerland	36 817	4849	7363 (20%)	970	56 578
Turkey	70 000	991	5500 (8%)	78	6511
UK	77 373	1273	8153 (11%)	134	45 549

Infact Angioplasty Project (NIAP) study in the UK, for example, the patients treated by p-PCI were younger than those treated by TL, suggesting a tendency to use p-PCI in fitter patients who have a lower predicted mortality regardless of treatment strategy. Conversely, it is also possible that some of the difference is due to the 'real world' inclusion of higher risk patients, for whom the differential benefits of PCI might be greater. The highest risk patients (elderly, cardiogenic shock, polymorbid, etc.) are usually excluded from the randomized trials and p-PCI is certainly an optimal treatment for this high-risk group, while TL is associated with high mortality or high complication rates in cardiogenic shock or elderly patients.

The lack of information about the baseline characteristics of individual patients in our study and subsequently the inability to statistically compensate for probable differences between the two reperfusion groups prohibit us from making any adjusted comparison of mortality outcome between p-PCI and TL. However, properly analysed consecutive STEMI patients from a whole European country (Sweden) showed that p-PCI was superior to TL with lower 30 day and 1 year mortality.[31,32]

Time delays

If 30 min (as an expected minimal time to achieve pharmacologic reperfusion) are arbitrarily added to FMC-needle time, then TL is only minimally faster in opening the coronary artery when compared with p-PCI in our study. The importance of time delays can be easily demonstrated on the situation in France: the time delays in reperfused patients are short and thus the mortality is low. Furthermore, the difference (125 min; *Table 5*) between the short TL-related delay and the long PCI-related delay causes no significant difference in mortality between the two treatment strategies in this country.[33] In other words, p-PCI is superior to TL only when the time difference between these two strategies is below 2 h. We are fully aware that this survey cannot directly compare

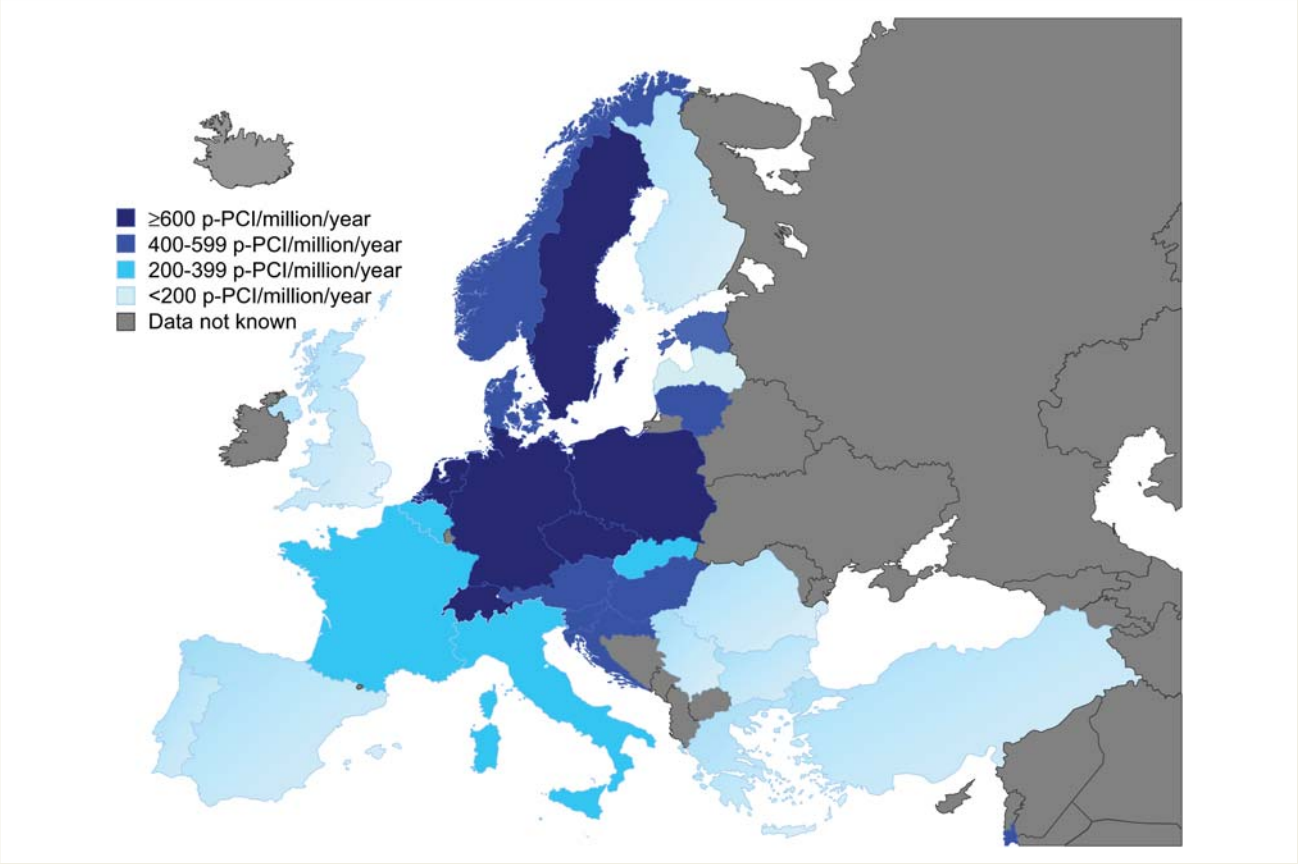

Figure 2 Primary PCIs per year per million inhabitants in European countries. Grey colour, no data available; blue colour, countries participating in this study.

TL and p-PCI. Both treatments can certainly be offered more expeditiously than was shown in this study. This should be one of the main goals for future improvements.

Primary PCI volume per centre and per operator

Primary PCI volume per centre *and per operator* may influence the outcomes, especially of STEMI patients, where the complexity of care is more important compared with elective PCI. Unfortunately, this study was not designed to collect such data. The experience from countries, using primary PCI for vast majority of their STEMI patients, shows that a population between 0.3 and 1.1 million per one primary PCI (i.e. non-stop, 24/7) centre results in ca. 200–800 primary PCI procedures/year/centre. This may be considered optimal. Population per centre <0.3 million results in low numbers of STEMI and thus the experience of the team may not be sufficient. A population significantly greater than one million results in 'overload' of the centre by too many infarcts (of course only if all infarcts from that region are admitted to this centre). The PCI volume per operator is probably less important than PCI volume per centre, as there are very few low volume operators in the high volume centres. The optimal case load may be anywhere between 50–100 primary PCIs/operator/year.

Reimbursement

In most European countries (Austria, Croatia, Czech Republic, Denmark, Germany, Greece, Hungary, Italy, Israel, Lithuania, the Netherlands, Norway, Poland, Portugal, Serbia, Slovakia, Slovenia, Sweden, and Switzerland), the reimbursement systems supports primary PCI—i.e. the PCI hospital is reimbursed adequately, the non-PCI hospital in general does not lose money by sending patients for primary PCI and Emergency Medical Services (EMS) transfers are reimbursed. In some countries, PCI centres receive reimbursement for primary PCIs, but the small hospitals lose money when STEMI patients are admitted initially to PCI centres (Belgium, Bulgaria, Spain, Turkey, and UK) or interhospital transfer is not appropriately reimbursed (Belgium and Bulgaria). In only one country (Romania), PCIs (any) are not adequately reimbursed in general (low limits on numbers of centres and procedures).

Barriers for the implementation of primary PCI in Europe

Reimbursement is only rarely a real problem (see above). EMS interhospital transport is not supported by adequate reimbursement in some countries, and in smaller districts only a single EMS ambulance is in service during the off-hours and cannot go

Table 4 Numbers of PCI centres and population per one centre

Country	All PCI centres	Population per any PCI centre	Primary PCI centres (non-stop, 24/7)	Population per primary PCI centre (24/7)
Austria	34	282 751	24	341 000
Belgium	36	294 015	30	352 817
Bulgaria	21	363 820	9	850 000
Croatia	10	449 331	8	561 664
Czech Republic	22	464 943	22	464 943
Denmark	7	781 160	5	1 093 624
Estonia	3	438 637	2	657 956
France	210	297 376	200	312 245
Finland	24	220 853	2	2 650 242
Germany	430	190 000	310	265 000
Greece	40	267 657	10	1 071 000
Hungary	16	622 257	13	765 854
Italy	242	240 270	164	354 559
Israel	22	333 500	16	458 563
Latvia	5	454 179	1	2 270 894
Lithuania	6	595 906	3	1 191 813
F.Y.R.Macedonia	3	683 204	3	683 204
The Netherlands	22	745 700	22	745 700
Norway	8	587 500	6	783 963
Poland	95	405 455	74	520 516
Portugal	19	560 158	9	1 182 555
Romania	12	1 856 338	0	N.A.
Serbia	9	822 222	1	7 400 000
Slovakia	6	916 666	4	1 375 000
Slovenia	5	401 849	2	1 004 745
Spain	129	349 743	56	805 658
Sweden	29	311 417	13	694 699
Switzerland	27	281 240	20	379 675
Turkey	157	449 592	35	2 016 742
UK	98	620 165	23	2 642 445

Primary PCI centre (24/7) was defined as PCI hospital not using thrombolysis for the treatment of STEMI patients, in other words hospital performing primary PCI in all STEMI patients, 24 h/day and 7 days/week.

outside this district. Low staffing levels (lack of interventional cardiologists and/or nurses and other support staff) prevent many smaller PCI hospitals running a non-stop (24/7) primary PCI services. A conservative attitude of internists and even some noninvasive cardiologists, who still prefer to use TL instead of sending their patients to other cardiologists, is the most frequently quoted barrier, along with the insufficient motivation of interventional cardiologists and/or nurses to run the non-stop (24/7) services even when the staffing is sufficient (they are often not paid adequately for this activity). The use of helicopters for *short* distance transfers actually prolongs the delays and should in general be avoided; helicopter transfer is extremely useful for patients with *long* distance transfers but is expensive. In several countries (Austria, Croatia, Czech Republic, Norway, and Sweden), the good cooperation between the national society of cardiology, government, and insurance companies (health care funds) significantly contributed to the development of p-PCI services.

This survey suggests that medical and non-medical staff are the main barriers for wider p-PCI implementation: with reasons ranging from low staffing levels (lack of interventional cardiologists and/or nurses and other staff groups) through to the conservative attitude of many physicians and to the insufficient motivation of interventional cardiologists and/or nurses to run demanding non-stop (24/7) services. In some countries, the lack of a systematic training program has resulted in a lack of interventional cardiologists and foreign cardiologists have been invited to work there in order to fill this gap. An inappropriate reimbursement system is the limitation of p-PCI only in a few countries. Some of these problems might be overcome by organizing cooperating networks of PCI hospitals in close vicinity and organized by the local

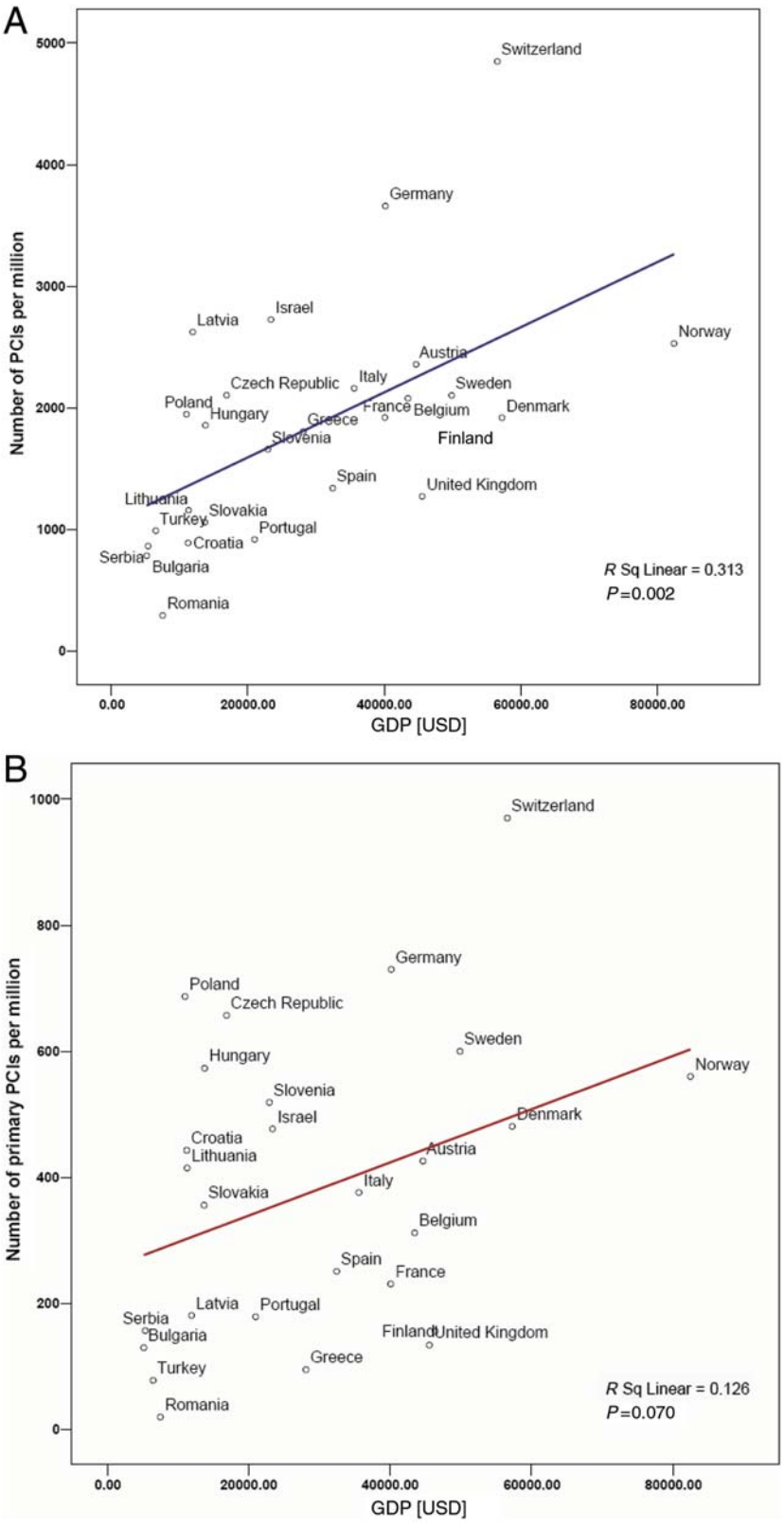

Figure 3 Correlation between the annual number of PCI procedures per million population and the gross domestic product per capita in European countries. (*A*) All PCI procedures. (*B*) Primary PCI procedures.

Table 5 In-hospital mortality (in %) of acute myocardial infarction

Country	All STEMIs	STEMIs treated by primary PCI	STEMIs treated by thrombolysis	All AMIs (STEMI+ non-STEMI)
Austria	12	5	8	N.A.
Belgium	6.6	5.1	7	N.A.
Bulgaria	N.A.	N.A.	N.A.	N.A.
Croatia	10	5	7	N.A.
Czech Republic	8.6	6.7	N.A.	6.3
Denmark	N.A.	N.A.	N.A.	N.A.
Estonia	N.A.	N.A.	N.A.	N.A.
France	6.6	5.0	4.3	5.4
Finland	11.9	N.A.	N.A.	11.8
Germany	6.8	5.3	7.8	6.1
Greece	8.9	3.6	5.1	7.7
Hungary	9.1	5.7	13	13.5
Italy	13.5	3.1	3.5	11.1
Israel	4.2	N.A.	N.A.	2.8
Latvia	11.7	2.3	10.1	10.9
Lithuania	N.A.	6	N.A.	N.A.
F.Y.R.Macedonia	N.A.	4	7	N.A.
The Netherlands	N.A.	N.A.	N.A.	N.A.
Norway	N.A.	3.5	N.A.	8.5
Poland	8.5	4.2	12	7.5
Portugal	7.8	N.A.	N.A.	6.0
Romania	13	7	8.5	N.A.
Serbia	9.9	3.3	9.3	10.7
Slovakia	9.4	3.2	11.1	N.A.
Slovenia	N.A.	6.2	N.A.	N.A.
Spain	N.A.	4	N.A.	N.A.
Sweden	6.2	3.8	8.8	5.2
Switzerland	6.2	3.6	4.5	5.0
Turkey	11	8	14	14
UK	9	3.7	7.3	8.7

ambulance system (EMS) as shown from the VIENNA STEMI network.[34] The formation of local networks might help to reach the goal.[35]

Limitations of this analysis

While data from 30 countries were included in this analysis, the number of centres that participated in some of the national registries or surveys may not be representative of the countries' total populations. In addition, data were not gathered during the same period of time (data from countries are based on 2005, 2006, or 2007 registries or surveys depending on what was available in each country at the time of this manuscript preparation). Furthermore, different inclusion criteria to national registries and surveys may lead to selection bias in the patient population. This manuscript cannot objectively compare p-PCI vs. TL. It is possible that hospitals using primary PCI have better resource allocation and organization that allows for better overall management of all aspects of AMI, e.g. staffing of these centres may play an important role. Furthermore, we did not have individual patient level data and it may well be that the patients treated by p-PCI and TL are not matched (e.g. p-PCI patients might be younger than the lytic cohort) and thus caution is needed in making such non-randomized comparisons. The presented data are unvalidated, derived from national registries or surveys that might not have identified all patients with AMI or STEMI. The various registries used here differ from each other in their methodology, this being the major limitation that led us to the decision not to use sophisticated statistics in this manuscript.

Due to the facts that this is a retrospective analysis of multiple national registries, there is a lack of rigour in defining the same entry criteria to these variable registries. Furthermore, the data about all hospital admissions (including non-PCI hospitals) were available only from 16 countries. In the remaining 13 countries, data were limited mostly to PCI centres (plus partial information about admissions to non-PCI hospitals).

Table 6 Median time delays (in min) in reperfusion therapy

Country	Symptoms onset: first medical contact (FMC) time	FMC-thrombolysis (needle) time	FMC-primary PCI (balloon) time
Austria	90	30	115
Belgium	180	30	60
Bulgaria	N.A.	N.A.	N.A.
Croatia	140	N.A.	120
Czech Republic	150	N.A.	120
Denmark	N.A.	N.A.	N.A.
Estonia	N.A.	N.A.	N.A.
France	68	57	170
Finland	N.A.	N.A.	N.A.
Germany	100	45	120
Greece	180	N.A.	95
Hungary	210	110	115
Italy	117	30	88
Israel	90	73	92
Latvia	N.A.	N.A.	N.A.
Lithuania	60	N.A.	120
F.Y.R.Macedonia	147	N.A.	154
The Netherlands	N.A.	N.A.	N.A.
Norway	N.A.	N.A.	N.A.
Poland	118	N.A.	124
Portugal	N.A.	60	86
Romania	176	42	N.A.
Serbia	60	N.A.	177
Slovakia	175	65	110
Slovenia	97	N.A.	134
Spain	118	45	97
Sweden	120	40	69
Switzerland	90	94	135
Turkey	N.A.	N.A.	N.A.
UK	68	55	118

In some countries, the FMC time is not reported and instead, the door-needle or door-balloon times are in the table.

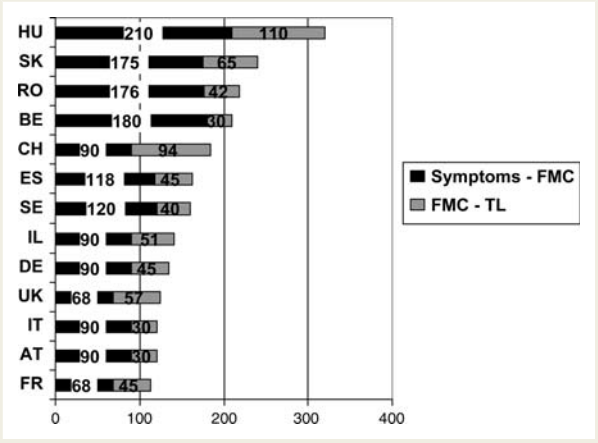

Figure 4 Time delays in patients treated by thrombolysis: 'symptom onset—first medical contact' and 'first medical contact—start of thrombolysis' time.

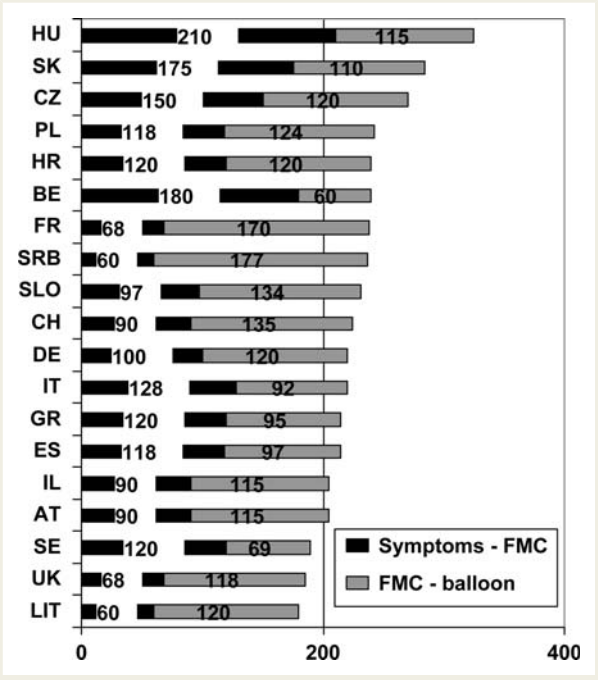

Figure 5 Time delays in patients treated by p-PCI: 'symptom onset—first medical contact' and 'first medical contact—balloon' time.

However, despite these limitations, we believe that these data are the best available and have clear clinical relevance.

Conclusions

The annual incidence of hospital admission for AMI in Europe is circa 1900 patients per million population with an incidence of STEMI of about 800 per million. A nationwide primary PCI strategy for STEMI results in more patients being offered reperfusion therapy. North, West, and Central Europe have already well-developed primary PCI services, offering primary PCI treatment to 60–90% of all STEMI patients. South Europe and the Balkans are still predominantly using TL—associated with this is a higher proportion of patients left without reperfusion treatment. Countries performing annually >600 primary PCIs per million population and having a mean population per one p-PCI centre <750 000 are able to meet the needs of all their STEMI patients. Countries in which (nearly) all existing PCI centres offer 24/7 p-PCI services appear to exhibit the best results. Overall, there

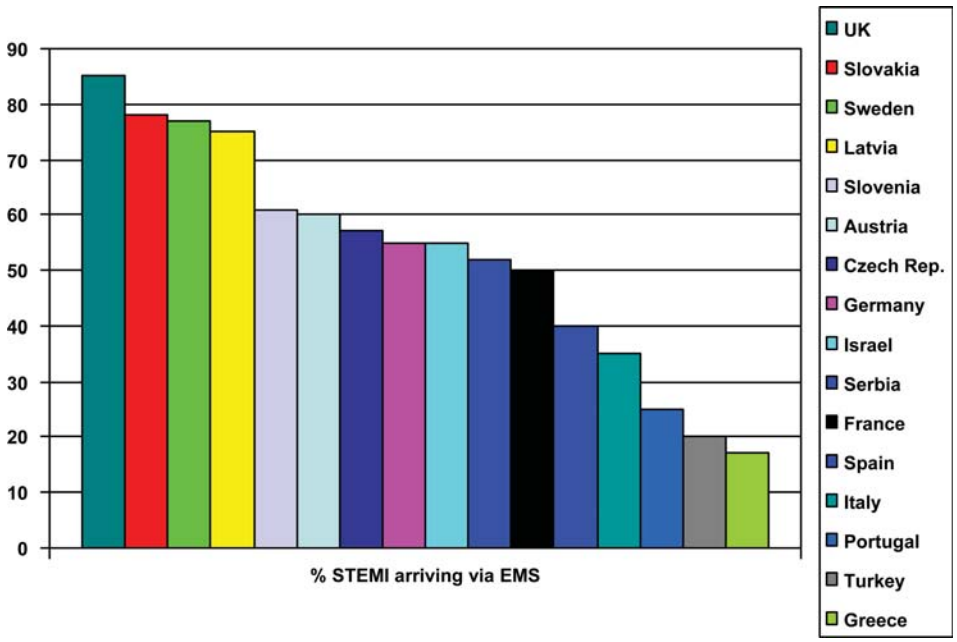

Figure 6 Percentage of STEMI patients arriving to the first hospital via EMS services. In the UK, Norway, Switzerland, and Sweden, physicians are only in ambulance helicopters, paramedics are in ambulance cars. In all other countries, physicians are in most or all EMS ambulances (cars and helicopters).

is a substantial heterogenity of practice in Europe and there are many opportunities to improve the care.

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Conflict of interest: none declared.

Appendix

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People's corner: New position

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Nikolaus Marx, Professor of Medicine/Cardiology and Head of Internal Medicine I, Aachen University, Germany

Nikolaus Marx, born in 1968, was appointed to the above position in 2009. He received his medical training at the Universities of Mainz, Geneva (Switzerland) and Düsseldorf, obtaining his MD in 1994. His thesis on growth regulation in human renal cancer cell lines was completed at the laboratory of Prof. Gerharz at the Institute of Pathology, Mainz University. After a post-doctoral Fellowship with Dr Peter Libby and Dr Jorge Plutzky at Brigham and Women's Hospital, Harvard Medical School, Marx later became a board-certified internist, then cardiologist, before specializing in intensive care medicine in internal medicine at the University of Ulm.

Marx is a member of several organizations in the field of cardiology and diabetes, including the European Society of Cardiology, American Heart Association (AHA), German Diabetes Association, and the European Association for the Study of Diabetes. In addition to reviewing submitted manuscript to numerous journals, including *Circulation*, *Diabetologia*, *Diabetes*, *Diabetes Care*, *The Journal of Immunology*, and *The Lancet*, he is currently Associate Editor for *Diabetes and Vascular Disease Research*. Marx was awarded the Servier Young Investigators Award in 1999 at the First European Meeting on Vascular Biology and Medicine. More recently, he was the winner of the Poster Award Competition in Epidemiological Science at AHA 2002, the 2004 Morgagni Young Investigator Award, as well as the Rising Star Award 2005 of the European Association for the Study of Diabetes (EASD).

He has a longstanding scientific interest in the role of diabetes in vascular disease and the anti-inflammatory role of nuclear receptors in vascular cells. In his new position in Aachen, Marx will pursue his work in this area, extend the established scientific interest of the department in interventional cardiology, and strengthen the research area of non-invasive imaging together with other groups from the technical university of Aachen (RWTH).

Outside of medicine, Marx has a family with a daughter and two sons and is a passionate skier.