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An Internet-based registry of acute myocardial infarction in Switzerland[1]

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Summary

Background and objectives: Evidence-based medicine, derived from randomised controlled clinical trials, is now the main standard for defining management of cardiovascular disease. It is therefore important to obtain information from the clinical arena: (1) to update information on the prognosis of cardiovascular disease in the "real world"; (2) to assess how new knowledge is put to use at a national level; (3) to help individual health providers put their current practice into perspective.
Methods and results: Since January 1997, we have started an internet-based registry of hospital admissions for Acute Myocardial Infarction in Switzerland (AMIS). Over a 2-year period, 50 hospitals included 3574 patients, of whom 3138 had a known hospital outcome following definite or probable AMI. Hospital mortality was 11.2%. Using parameters available at admission, it correlated significantly with: age >65 years (OR 3.8), history of cerebrovascular disease (OR 1.8), active or ex-smoker status (OR 0.6), need for defibrillation prior to admission (OR 4.0), left bundle branch block (OR 2.0) or ST segment elevation (OR 1.5) on the first ECG, and higher Killip class (OR 2.1, 5.5 and 17.0 for Killip class II, III and IV respectively. 47% of patients received acute reperfusion therapy, 94% aspirin, 63% betablockers, and 37% ACE inhibitors.
Conclusions: In-hospital mortality following myocardial infarction remains high. Early risk stratification is possible and may allow improved referral patterns. Internet and/or computer-based data collection is functional, flexible, and fast; it gives individual hospitals the opportunity to assess and adapt their performance in a continuous fashion.
Keywords: myocardial infarction; treatment guidelines; Internet

Résumé

Contextes et objectifs: La médecine basée sur les preuves, telle qu'elle est définie par les résultats d'études randomisées prospectives, est actuellement devenue la référence principale pour la définition du traitement des affections cardio-vasculaires. Dès lors, il devient important d'obtenir une information supplémentaire de la pratique clinique courante afin de: (1) Mettre à jour nos connaissances quant au pronostic de la maladie cardio-vasculaire dans la «vraie vie»; (2) evaluer la façon dont les connaissances récentes sont mises en pratique au niveau national; (3) aider les institutions individuelles à mettre leur activité en perspective par rapport à une norme actuelle.
Méthodes et résultats: Depuis janvier 1997, nous avons mis en place un registre sur Internet des admissions hospitalières pour l'infarctus aigu (AMIS = Acute Myocardial Infarction in Switzerland). Durant une période initiale de deux ans, 50 hôpitaux ont inclus 3574 patients, dont 3138 avaient une évolution hospitalière documentée à la suite d'un infarctus considéré comme certain ou probable. La mortalité hospitalière fut de 11,2%. Cette mortalité était en relation avec un âge supérieur à 65

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ans (RR 3,8), une anamnèse d'accident vasculaire cérébral ancien (RR 1,8), un tabagisme ancien ou actif (RR 0,6), la nécessité de recourir à une défibrillation avant l'admission (RR 4,0), un bloc de branche gauche (RR 2,0) ou une élévation des segments ST (RR 1,5) sur l'ECG à l'admission et une classe Killip plus élevée (RR 2,1–5,5 et 17,0 pour les classes Killip respectivement II, III et IV). 47% des patients furent traités par une thérapie de reperfusion aiguë, 94% reçurent de l'Aspirine, 63% des bêtabloquants et 37% des inhibiteurs de l'enzyme de conversion.

Conclusions: La mortalité hospitalière de l'infarctus aigu du myocarde reste élevée. Une stratification précoce du risque est possible et pourrait permettre d'améliorer les transferts de patients sélectionnés. Une collecte de données informatisée, utilisant largement l'Internet, est fonctionnelle, flexible et rapide. Elle donne aux hôpitaux individuels la possibilité d'évaluer et d'adapter leur performance sur un mode continu.

Introduction

Evidence-based medicine is profoundly changing the practice of medicine today. Nowhere is this more obvious than in the field of cardiovascular disease, and the management of acute myocardial infarction in particular [1–5]. International and national guidelines are published [6, 7], defining appropriate therapy. It therefore becomes important to obtain some feedback from the "real world" to evaluate how such recommendations are implemented in everyday practice, and to assess the changes that follow newly acquired knowledge. This is all the more important since randomised controlled trials [1–5] sometimes give a partial and distorted view of the overall population of patients admitted to hospital for acute myocardial infarction. The inclusion and exclusion criteria used frequently exclude some of the sickest patients, and in-hospital mortality is therefore generally underestimated [8].

Since January 1997, we started a national Internet-based registry of hospital admissions for Acute Myocardial Infarction in Switzerland (AMIS). The goals of this project are: (1) to better define the current in-hospital prognosis of myocardial infarction; (2) to allow continuous real-time quality control at the national, regional and individual centre level; (3) to evaluate compliance with guidelines for myocardial infarction management. The present paper presents the AMIS project and is focused on acute management and in-hospital prognosis of patients with myocardial infarction in 1997–1998.

Methods

During 1995 and 1996, a first pilot project (PIMICS), targeted at patients hospitalised for myocardial infarction, was carried out in 73 hospitals in Switzerland, and the results have been published [9]. Following this, the collected data set was fully redefined during the course of 1996, a computer-based data entry was designed, using either diskettes or the Internet for transfer to the data centre, and patient inclusion in AMIS began on January 1, 1997. During the 4th quarter of 1996, all hospitals caring for acute admissions in Switzerland were contacted, irrespective of whether they were equipped with a coronary care unit or not. At the time of this writing, 50 such centres are including their myocardial infarction patients in the AMIS project registry.

All patients admitted to the emergency room, the intensive care unit, or an ordinary ward, are candidates for inclusion in the AMIS registry, if the clinical diagnosis of acute myocardial infarction has been made by the treating physicians at the time of discharge or death. There are no exclusion criteria. A small number of patients may be included several times if they are transferred from one hospital to another inside Switzerland, but information in the registry form enables the data centre to correct for this. Three composite parameters are taken into account for establishing the diagnosis of myocardial infarction. (1) Symptoms, considered "typical" if consisting of chest pain, and/or abrupt shortness of breath and/or syncope; (2) ECG changes with ST segment elevation or depression, or left bundle branch block; (3) plasma peak creatine phosphokinase above twice the upper limit of normal and CKMB fraction of 8% or more at any time during the hospital stay or during the 2 weeks preceding admission. Using the information given in the registry for each included patient, three categories of diagnostic certainty are determined: "definite" myocardial infarction if all three parameters are positive, "probable" if only two, and "possible" if only one is positive. Although some selection bias is associated with such categorisation, since some of the sickest patients may die before an ECG can be taken or before the plasma levels of cardiac enzymes have time to rise, it is applied to avoid excessive heterogeneity in myocardial infarction reporting between participating centres. For the purpose of the present report, only patients with a definite or probable diagnosis of myocardial infarction are considered.

The current "core" database comprises 109 data items. They include information regarding past history, known cardiovascular risk factors, acute symptoms and out-of-hospital management, clinical presentation, early (first 48 hours) management, overall hospital course, diagnostic tests used or planned and medication at discharge, length of stay and destination following discharge. Each patient is only identified by a number, so that all data are anonymous once they are incorporated into the central database. No paper forms are necessary for the data entry, rather, it is made directly into a computer using one of two systems. The AMIS website (http://

www.epidemiology.ch) is accessed via the Internet, and after the appropriate password has been given, the data can be entered directly into the main database. For hospitals who do not yet have ready access to the internet, the data is stored locally on a DOS compatible program based on Epi-Info [10] and periodically downloaded to a diskette that is then sent to the data coordinating centre. On the Internet questionnaire, several data items are compulsory, making a blank field unacceptable by the program. There are also built-in checks for inconsistencies, thus reducing the need for centralised "data cleaning" after it has reached the data centre. Complete data entry for an individual patient takes about 10 minutes. At present, feed-back information is given to participating centres on a 6month basis, enabling them to assess their activity in comparison with the overall AMIS registry, but no information on individual centres is given to other participants, or to any outside agencies. Because of the instantaneous nature of data input when the Internet is used, it has recently become possible to implement on-line feedback to those individual centres that are connected to it. This allows each centre to use the database as a local tool, while contributing as well to the national registry. AMIS was conceived as an open-ended project, and if continued funding can be secured, it is planned to continue with long-term data collection. When all participants will be using the Internet for data transfer, it will be technically quite easy to modify the structure of the database. This could be needed to adapt to the evolution of medical knowledge or to answer specific questions during a limited period of time, using "satellite registries" that could be temporarily added on to the main structure.

Statistical analysis

Hospital mortality was calculated in two ways: (1) as a simple count or simple proportion of deaths (= number of deaths/total number of patients); or (2) via Kaplan-Meier (product-limit) survival analysis methodology [11]. Logistic regression models [12] for predicting hospital mortality from a set of variables available at hospital admission were also fitted. These variables included age, gender, Killip class, admission delay, history of previous coronary artery disease, history of cerebrovascular disease, history of high blood pressure, history of diabetes, history of hypercholesteremia, history of smoking, cardio-pulmonary resuscitation, defibrillation, and any specific changes in the ECG (left bundle branch block, Q-wave, ST elevation). For ease in interpreting the resulting models, Killip classes II, III and IV were coded as dummy variables (Killip class I = reference category), age was coded as >65 vs. <65 years, history of smoking was coded as current or ex-smoker vs. never smoked, and admission delay was coded as <6 hours vs. >6 hours or missing). This latter departure from the usual practice of excluding patients with missing data (only used for admission delay) was done for the purpose of increasing the sample size in the multivariate models; in any case, the results were qualitatively similar with or without this convention. Separate univariate logistic models were first fitted for each admission variable. We then used backward stepwise elimination (significance level 0,05) for the purpose of selecting a "best" subset of hospital mortality predictors from the whole set of admission variables. The final multivariate model was based on n = 2,734 (260 dead + 2,474 alive) AMIS patients (404 (12.9%) of patients with incomplete data excluded). Odds ratios (OR) were simultaneously adjusted for all the other predictors included in the multivariate logistic regression model.

Results

Between January 1997 and December 1998, 3574 patients were included in the AMIS registry by the 50 participating centres. Using the predefined criteria described above, 3197 patients were considered to be have suffered a "definite" (n = 2045) or "probable" (n = 1152) myocardial infarction. Among these two categories, 59 patients with missing data on hospital mortality status were excluded. Patients with only "possible" myocardial infarction (n = 377) were also excluded. The present study is therefore based on 3138 patients with definite or probable myocardial infarction. The 50 participating hospitals comprised 8 (16%) large (>500 beds), 15 (30%) medium size (200–500 beds) and 27 (54%) small (<200 beds) hospitals.

Patient demographics and acute phase charac-

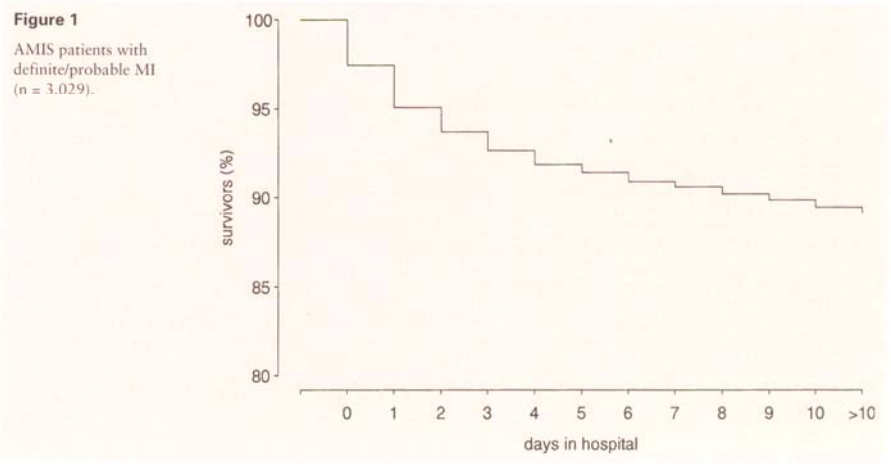


Figure 1
AMIS patients with definite/probable MI (n = 3.029).

Figure 2

Relation of Killip class at admission with hospital mortality.

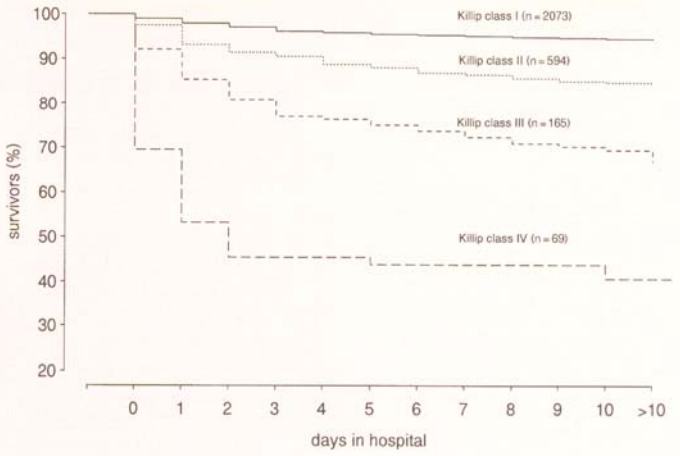


Table 1

Demographics and acute phase characteristics of 3138 AMIS patients with "definite" of "probable" acute myocardial infarction.

	n	%	% with missing data
patients with "definite" or "probable" AMI	3138	100.0	0
age <65 years (mean age entire cohort = 65.5 ± 12.8 years)	1339	43.5	1.8
male gender	2224	72.0	1.6
past medical history			
coronary artery disease	1137	37.0	1.9
cerebrovascular disease	220	7.2	1.9
high blood pressure	1461	47.8	2.7
diabetes	587	19.2	2.8
hyperlipidemia	1428	50.4	9.7
current or previous smoking	1848	61.7	4.5
delay from symptom onset to hospital admission			
<6 hours	1624	59.6	13.0
7–11 hours	346	12.7	
>12 hours	753	27.7	
out-of-hospital management			
cardiopulmonary resuscitation (CPR)	232	7.5	1.4
DC shock	111	3.6	1.1
hemodynamic status at admission			
Killip class I	2142	71.5	4.5
Killip class II	617	20.6	
Killip class III	167	5.6	
Killip class IV	72	2.4	
ECG at admission			
ST segment elevation	2180	70.3	1.2
Q wave present	1169	37.6	1.0
left bundle branch block	23	7.6	1.2
anterior localization	1264	40.9	1.5
inferior localization	1446	46.8	1.5
undetermined localization	381	12.3	1.5
hospital mortality	351	11.2	0
10 day Kaplan-Meier mortality	10.5 + 0.6% (95%CI = 9.4–11.7%)		3.5

Table 2

Acute management during initial 48 hours.

	n	%	% with missing data
intravenous thrombolysis	1133	36.4	0.7
immediate ("direct") PTCA within 12h following admission	237	7.6	
IV thrombolysis and/or direct PTCA and/or coronary bypass surgery within 48 hours (i.e. early myocardial reperfusion therapy)	1426	47.0	3.3
DC shock for VT or VF	211	6.8	1.7
tracheal intubation	204	6.6	1.6
aspirin	2935	93.9	0.4
other antiplatelet medication	418	13.5	1.5
heparin	2900	92.7	0.3
IV nitrates	2615	84.1	1.0
betablockers	1967	63.1	0.7
angiotensin converting enzyme inhibitors	1147	37.0	1.2
calcium channel blockers	161	5.2	1.4
lidocaine	286	9.2	1.3
digitalis	163	5.3	1.2
amiodarone	119	3.9	1.6
opiates	1774	57.5	1.7

VT: ventricular tachycardia, VF: ventricular fibrillation

Table 3

Multivariate logistic regression model for predicting hospital mortality at admission (n = 2734).

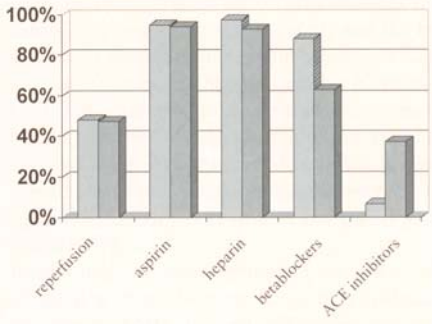
predictor		odds ratio (OR)	(95% confidence interval for OR)
age >65 years		4.0	(2.7, 6.0)
Killip class	I	1.0	–
	II	2.1	(1.5-2.8)
	III	5.4	(3.5-8.3)
	IV	17.0	(9.0-32.1)
delay >6 hrs. or undetermined		1.4	(1.1, 1.9)
history of cerebrovascular disease		1.8	(1.2, 2.7)
current/ex-smoker		0.6	(0.5, 0.8)
defibrillation prior to admission		4.0	(2.3, 7.0)
left bundle branch block		1.9	(1.3, 3.0)
ST segment elevation		1.5	(1.1, 2.0)

Note: for Killip class II,III and IV, the OR reflects the incremental risk of hospital mortality vs. Killip class I (reference category). For all the other predictors, the OR reflects the incremental/decremental risk for presence vs. absence.

teristics are given in table 1, together with the hospital outcome. Medication, intensive care management, and reperfusion strategies used during the first 48 hours in hospital are described in table 2. Time of hospital death is given in figure 1. The relation of Killip class [13] at admission with hospital mortality is depicted in figure 2. Univariate analysis of admission characteristics impacting on hospital mortality revealed that 13 parameters were significantly associated with an increased or decreased mortality: age >65 years (OR 5.1, CI 3.8–7.0), higher Killip class (OR 3.0, CI 2.6–3.4 for each additional class), female gender (OR 1.8, CI 1.4–2.2), delay from pain onset to hospital admission >6 hours (OR 1.5 CI 1.2–1.8), known prior coronary artery disease (OR 2.1, CI 1.7–2.7), known prior cerebrovascular disease (OR 3.0, CI 2.2–4.2), hypertension (OR 1.5, CI 1.2–1.8), diabetes (OR 2.1, 1.6–2.6), hyperlipidemia (OR 0.6, CI 0.5–0.8), current/ex-smoker (OR 0.5, CI 0.4–0.6), need for pre-admission cardiopulmonary resuscitation (OR 2.1, CI 1.5–3.0) or defibrillation (OR 3.6, CI 2.4–5.5), and left bundle branch block present (OR 3.7, CI 2.7–5.0). Multivariate analysis of mortality predictors is given in table 3. An example of the information made available to individual centres is given in figure 3.

Figure 3

Treatment applied in hospital X (striped bars) vs. the entire AMIS database (grey bars) during the first 48 hours following admission.



Reperfusion includes intravenous thrombolysis and/or immediate PTCA.

	hospital X	entire AMIS
reperfusionn (%)	48	44
aspirin (%)	95	94
heparin (%)	97	93
betablockers (%)	88	65
ACE-inhibitors (%)	7	37

Discussion

The AMIS concept

To our knowledge, this constitutes the first report of a continuous multicentre registry for acute myocardial infarction, offering the possibility of both data input and data analysis via the Internet. The present overview demonstrates the feasibility for clinicians of implementing such a tool, so as to maintain access to their own data, and to have a powerful online quality control instrument for monitoring their daily practice. This is made possible thanks to continuous linking with the epidemiologists and statisticians at the data centre "hub", a type of direct collaboration that is not usually available to many small or medium-sized hospitals. The continuous, ongoing nature of the project is also associated with several added benefits: (1) it should eventually make it possible to recruit all patients admitted to hospital with myocardial infarction in Switzerland; (2) it allows the accrual of a large and representative population of patients with acute myocardial infarction, and will enable better definition of trends over time; (3) it will make it possible to attach temporary "satellite" elements to the main core of data, in order to answer specific questions, without interrupting the project.

Other published registry series of myocardial infarction patients [14–22] have usually been based on prospective data collection, but some have selected patients retrospectively, using either administrative coding or the clinical discharge diagnosis. None has used the Internet for collecting and transmitting data. Information feedback to individual participating centres appears not usually to have been provided while the data were being collected. Also, many series have focused on a time-window limited to several months or weeks [17, 20, 21]. This makes them less well suited for the return of clinically useful information to the individual participating centres, and for the evaluation of the potential impact of this information on daily clinical practice.

Hospital mortality

Mortality from coronary artery disease has previously been evaluated in selected areas of Switzerland [22], but the specific topic of hospital outcome following myocardial infarction was not addressed. The PIMICS project [9] represents the first effort targeted at acquiring data on this patient subset for Switzerland as a whole during a preset limited period of time. During 1995–1996, 3877 patients were included, using a paper-based data entry. It was on the basis of this first experience that the AMIS project was developed.

The 11.2% overall hospital mortality in AMIS remains higher than that reported in some of the recent major randomised controlled trials, where mortality rates have typically been in the 2.6–7.5% range for selected patients with myocardial infarction [3–5]. However, it is com-

parable to many of the recently published registries of myocardial infarction patients in Europe and the United States. Our earlier PIMICS project in Switzerland, using less stringent diagnostic criteria, documented a hospital mortality rate of 9.1%. The American National Registry of Acute Myocardial Infarction [14] reported a rate of 10.6% for 240989 patients, Gil et al. [19] observed a 11.4% hospital mortality during the 1990-3 period, Goldberg et al. [15] 11.7% for the period 1993–1995, and Mahon et al. [18] 18% for a selected population of referred patients. Some of the published registries suggest a markedly lower hospital mortality: Danchin et al. [17] report a 5 day mortality of 7.7% in a series of 2563 patients admitted to 373 intensive care units in France in 1995. Because the baseline demographics and main treatment options were similar to those used for the AMIS patients, it is unlikely that differences in patient care account for the higher mortality observed in our series. Rather, the inclusion in our registry of patients who were admitted to the emergency room, but who died before they were transferred to the ICU is an important difference, together with the longer follow-up period (entire hospital stay in AMIS vs. 5 days in the French registry). When only patients admitted to the ICU were selected from the AMIS population, at 5 days their Kaplan-Meier mortality was 8.2 + 0.5% (95% CI = 7.2–9.2%).

Mortality predictors at admission

Among the 8 parameters that emerged as predictors by multivariate analysis (table 3), the present data clearly document the major prognostic impact of both patient age and hemodynamic status at admission. This is in keeping with previously published data [14–22], although certain series did not include a graded categorisation of hemodynamic compromise, and/or did not include the presence or absence of shock among the analysed parameters [14, 20]. Patients with severe heart failure, and particularly those in cardiogenic shock are often excluded from randomised trials enrolling myocardial infarction patients [2, 3, 5]. This practice would appear questionable, in particular for large trials with a mortality endpoint, since it excludes the very patients who are exposed to the highest risk of dying.

The incidence of cardiogenic shock complicating myocardial infarction varies from 1.7 to 7.1%, and probably reflects both varying patient selection and the timeframe considered [25, 26]. In the present series, only shock at the time of admission was considered, and the incidence is therefore lower that when shock at any time during the hospital course is considered. The grim prognosis of shock has recently been confirmed by 2 randomised trials [27, 28], but a significant survival benefit has now been documented when immediate reperfusion by balloon angioplasty and/or bypass surgery is used [29].

Interestingly, although female gender was associated with an increased risk by univariate analysis in AMIS, this was no longer the case with a multivariate approach, and would suggest that age is the main determinant, rather than gender per se [30]. The mean age of female patients was 70.7 + 11.1 years and that of male patients was 63.4 + 12.7. Not all previous series are in agreement with this finding, however, and it has been suggested that female gender represents an independent risk factor for younger patients, but not for older ones [26]. As previously noted by others [19, 22], both smoking and hyperlipidemia were associated with a decreased risk of early death following myocardial infarction. This apparent paradox may derive [22] from the postulated more frequent association of smoking and hypercholesterolemia with focal thrombotic occlusion rather than with a more diffuse coronary disease pattern.

Overall, table 3 illustrates the fact that very early risk stratification should be possible for a large majority of myocardial infarction patients, and only requires readily available clinical and ECG information. More sophisticated techniques, such as echocardiography or nuclear medicine tests are thus not usually necessary for an initial prognostic evaluation in the emergency room. Very early appropriate decisions for transfer/referral from smaller hospitals to tertiary centres should therefore be possible in most instances. Certainly, all patients with any degree of hemodynamic failure, and selected elderly patients should be considered candidates if they do not respond to treatment within the very first hours. The potential need to react early to the presence of several indicators of poor prognosis is further underlined by the fact that half the patients who die during their hospital admission do so during the first 48 h. (fig. 1). Other approaches to predict hospital outcome following admission for myocardial infarction have been recently reported [3, 20–23]. Advanced age and presence of hemodynamic failure have systematically been found to be the most powerful predictors of hospital mortality. Other significant elements

have included: prior cardiac arrest, anterior infarction, high heart rate, low systolic blood pressure, raised serum creatinine, raised white blood cell count, thrombolysis rather than direct angioplasty, and small hospital size.

Compliance with current management guidelines

When compared to currently accepted standards of care, therapeutic interventions that were applied during the first 48 hours appear reasonably appropriate, as shown in table 2. Late admission to hospital (27.7% of patients were admitted beyond 12 hours after the onset of symptoms) together with lack of ECG evidence of transmural ischemia and/or left bundle branch block probably account for most cases who received no reperfusion therapy. Other recent series [9, 17] have suggested similar degrees of compliance. The use of calcium channel blockers and lignocaine is now relatively rare, in contradistinction to the situation prevalent a few years ago, and both betablockers and ACE inhibitors are widely prescribed. These trends are in accord with the more recently available data [6].

Study limitations

Although the ultimate goal of the AMIS project is to include all patients with myocardial infarction from all centres in Switzerland, this is not yet the case. The absolute number of patients does thus not currently give a true picture of the national incidence of myocardial infarction leading to hospital admission. This should hopefully improve over the next 2–3 years, as more centres join the project.

Quality and reliability of the information is a central issue when considering registry data, and using only discharge diagnosis or administrative classification codes to define a population of myocardial infarction patients can be significantly lacking in reliability. We did not implement any auditing in individual centres to check for consistency of database entries with the medical notes, but predefined definitions for myocardial infarction were applied to select a homogeneous population with "definite" or "probable" myocardial infarction. Patients with "possible" infarction were not included, although most of them probably did have true myocardial infarction: as a subgroup, their hospital mortality was 8.8%, and many of them may have died too early to develop a rise in their plasma CPK levels or to have an ECG taken.

Conclusions

1. Internet and/or computer-based data collection on myocardial infarction patients is functional, flexible, and fast; it allows frequent feed-back to individual participating centres who therefore are given the opportunity to assess their own performance in a continuous fashion against a national standard. This approach should allow early local improvements in therapeutic options to be made when needed.
2. In-hospital mortality following myocardial infarction remains high despite reasonable adherence to accepted management guidelines. At admission, a high Killip class and advanced age are the most powerful predictors of in-hospital mortality. Very early risk stratification is thus possible, and may allow better referral patterns to be implemented for selected patients.

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Appendix

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