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Abstract (250 w)

Aim

Coronary artery disease (CAD) has recently been emphasized as a major cause of sudden cardiac arrest (SCA) in young adults. We aim to assess the rate of immediate coronary angiography performance in young patients resuscitated from SCA.

Methods

From May 2011 to May 2017, all cases of out-of-hospital SCA aged 18 to 40 years alive at hospital admission were prospectively included in 48 hospitals of the Great Paris area. Cardiovascular causes of SCA were centrally adjudicated, and management including immediate coronary angiography performance was assessed.

Results

Out of 3,579 SCA admitted alive, 409 (11.4%) patients were under 40 years of age (32.3±6.2 years, 69.7% males), with 244 patients having a definite cause identified. Among those, CAD accounted for 72 (29.5%) cases, of which 64 (88.9%) were acute coronary syndromes. The rate of immediate coronary angiography was only 41.7% compared to 65.1% among those ≥ 40-years (P<0.001). During the study period, while the rate of immediate coronary angiography increased from 60.5% to 70.3% (P <0.001) in patients aged ≥ 40 years, the rate in patients aged less than 40 years remained stable (43.5% to 45.3%, P =0.795). Patients younger than 40 years were significantly less likely to undergo immediate coronary angiography (OR=0.34, 95% CI: 0.25-0.47), although early angiography was associated with survival at hospital discharge (OR=2.68, 95% CI: 1.21-6.00).

Conclusion

CAD is the first cause of SCA in young adults aged less than 40 years. The observed low rates of immediate coronary angiography suggest a missed opportunity for early intervention.

Key words – Sudden cardiac death; cardiac arrest; coronary artery disease; acute coronary syndrome; epidemiology; percutaneous coronary intervention

Introduction

Sudden Cardiac Arrest (SCA) is defined as a natural, unexpected and sudden pulseless event, without an obvious non-cardiac cause [1]. It is a significant public health concern, accounting for approximately 50% of cardiovascular deaths, with 300,000 cases estimated annually in Europe [2].

Coronary Artery Disease (CAD) accounts for around 80% of SCA cases [3]. Along with bystander interventions and early defibrillation, immediate percutaneous coronary intervention (PCI) is associated with improved outcomes after resuscitation from SCA [4][5][6][7][8]. Previous reports have shown an increase in the rate of coronary angiography performance in patients hospitalized alive after SCA [9][10]. In young patients, non-ischemic structural heart disease (especially cardiomyopathies) and electrical cardiac disorders are alternative diagnoses that were traditionally considered more prevalent [11][12]. However, the epidemiology of CAD has substantially changed over the last two decades, with significant changes in cardiovascular risk factors in early adulthood [13][14][15][16]. The proportion of young adults among STEMI victims has considerably increased over the last years [17]. Recent studies have reported that CAD was a major cause of SCA in young adults, in postmortem examination [18] and in SCA survivors [19]. This has potentially important implications for emergency decision-making in young subjects, especially with regard to early coronary angiography and PCI.

We undertook a population-based study of SCA patients admitted alive to hospital and hypothesized that young adults would be less likely to be referred for immediate coronary angiography at hospital admission due to perceptions of low CAD risk.

Methods

Study setting

The Paris-Sudden Death Expertise Center (SDEC) registry is an ongoing study which has been described previously [20][21][22][23][24]. Briefly, it is a comprehensive, prospective population-based registry comprising Paris and suburbs, encompassing a residential population of 6.7 million (approximately 10% of the total French population) and covering 762 km^2. In Paris, management of out-of-hospital cardiac arrest involves mobile emergency units (Service d'Aide Médicale Urgente), and firefighters (Brigade de Sapeurs Pompiers de Paris), with at least one trained emergency physician on board. Patients in whom a return of spontaneous circulation is achieved are then referred to a center with an intensive care unit (ICU) and coronary intervention facilities. Owing to a close collaboration with all the pre-hospital Emergency Medical Services (EMS), 48 hospitals, and forensic units, every case of out-of-hospital cardiac arrest aged ≥ 18 years occurring in the area is systematically enrolled in the SDEC registry, since May 2011. Exclusion criteria include age less than 18 years and cardiac arrest occurring outside the geographical area of interest. Regular external audits on the registry have shown that 99 % of cardiac arrest cases admitted alive to the hospital were detected [20].

The study was conducted in compliance with Good Clinical Practice, French Law and the French data protection law in accordance with the ethical standards laid down in the 1964 Declaration of Helsinki and its later amendments. Data file of the Paris-SDEC registry was declared to and authorized by the French data protection committee (Commission Nationale Informatique et Liberté, CNIL, DR-2012-445 authorization n°912309).

Study population

All SCA admitted alive to hospital were included from 15 May 2011 to 15 May 2017. According to definitions from the last consensus, SCA was defined as an unexpected out-of-hospital cardiac arrest without obvious non-cardiac cause, occurring with a rapid witnessed collapse within 1 hour after the onset of symptoms, or if unwitnessed, within the 24 hours after the last contact [1]. Those likely due to non-cardiac circumstances (such as trauma, drowning, hanging etc.) or prior terminal condition were not included. The present study specifically focused on young adults aged less than 40 years old.

Data collection

General data included demographic characteristics and location of SCA (residential or public place). Utstein templates for resuscitation information reporting were followed [25]. Pre-hospital data recorded included SCA circumstances, presence of a witness, witness-cardiopulmonary resuscitation before EMS arrival, presence of shockable rhythm before advanced life support, epinephrine dose injected by EMS, ST segment elevation on first electrocardiogram (ECG) recorded, and delays from collapse to basic life support and from call for EMS to arrival of EMS. In addition to the data from EMS and the medical examiner, a working group of the SDEC collected and assessed the lifetime past medical history. The information was gathered by the local medical staff, but two investigators thoroughly reviewed each medical report for data completion and validity, and provided final central adjudication (assigned diagnosis). In cases of divergent opinion, a third expert was asked to arbitrate. In survivors without definite diagnosis after the initial work-up performed in ICU, etiological medical investigations were carried out in cardiology, including cardiac magnetic resonance imaging, pharmacological tests, vasospasm provocative test, Holter-ECG recording, exercise stress test as well as genetic screening, all of which were actively encouraged by the coordinators of the study. The diagnosis of idiopathic ventricular fibrillation was made among survivors when eventually no phenotype was identified. Survival at hospital discharge and neurological status were also recorded. Favorable neurological prognosis was defined by a cerebral performance category (CPC) score 1 or 2, with 1 representing full recovery or mild disability and 2, moderate disability but independent in activities of daily living.

Definitions

Immediate coronary angiography was defined as that performed within the first two hours after ICU admission [26][27]. Significant CAD was defined by the presence of a stenosis producing > 50% narrowing in at least one coronary artery. Flow in coronary arteries was assessed using the thrombolysis in myocardial infarction (TIMI) classification. A coronary occlusion was defined as TIMI grade 0 to 1 flow. The occlusion was considered recent if collaterals were absent and if the occlusion was easily crossable by the wire during subsequent angioplasty. A culprit lesion was defined by the presence of a thrombus in the artery, a flow reduction < TIMI 3, and/or an acute coronary occlusion, requiring a revascularization by PCI (aspiration thrombectomy and/or angioplasty). Chronic ischemic heart disease-related SCA was defined as significant CAD diagnosed during coronary angiography in the absence of culprit lesion criteria or other non-cardiac SCA cause.

Statistical analysis

Continuous data were reported as mean ± standard deviation (SD) or median and interquartile range (IQR) for normally and non-normally distributed data respectively. Categorical data were reported as numbers and percentages. Comparisons used the $\chi 2$ or Fisher's exact test for categorical variables and Student's t test or Mann–Whitney–Wilcoxon test, when appropriate, for continuous variables. Multiple logistic regressions were used (i) to compare the rate of immediate coronary angiography at hospital admission according to patient's age, and (ii) to assess the association between immediate coronary angiography performance and survival rate at hospital discharge. The main known pre-hospital outcome predictors were included as explicative variables in the former model (age, gender, location of SCA, witness presence and witness-cardiopulmonary resuscitation, delays from collapse to basic life support and from call for EMS to arrival of EMS, presence of a shockable rhythm, epinephrine use), as well as ST segment elevation on first recorded ECG. Main comorbidities were also included in the second model. Variables significantly associated ($P < 0.20$) in univariate analysis were assessed in multivariate logistic regression. Linear time trends analysis on the rate of immediate coronary angiography were tested with the use of logistic regression dividing this 6-year study in 3 periods of 24 months. Missing data on study variables were no more than 10%, except for ST segment elevation on first ECG (12.0%) and interval from collapse to basic life support (12.3%), and were handled using case-complete analysis. Results were considered statistically significant at $P < 0.05$. All analyses were two-tailed. Statistical analysis was performed using R software, version 3.3.2 (R Project for Statistical Computing).

Results

Population

From May 15th, 2011 to May 15th, 2017, among 3,579 comatose patients admitted alive to 48 different hospitals after SCA, 409 (11.4%) were aged less than 40 years. Clinical and demographic characteristics of the young SCA group are summarized in Table 1. Mean age was 32.3±6.2 years with 285 (69.7%) males. Compared to patients older than 40, younger patients had fewer cardiovascular risk factors, comorbidities, or previously diagnosed heart disease (15.8% vs. 35.3%, P<0.001), especially CAD (1.1% vs. 20.1%, P<0.001). ST-segment elevation was less frequently recorded in the initial ECG (23.5% vs. 34.2%, P<0.001), family history of SCA was more frequent (8.0% vs. 1.8%, P<0.001), and SCAs were more often sports-related (12.2% vs 4.1%, P<0.001). The survival rate at hospital discharge was comparable between the two groups (31.6% vs 27.4%, P=0.103).

Causes of SCA among the Young

Among young SCA patients, the cause was uncertain in 165 (40.3%) cases due to early death and negative or incomplete initial work-up in ICU. Among 244 young adults with a definite etiology identified, a non-cardiac cause was diagnosed in 72 (29.5%) patients, and a cardiac cause was identified in 172 (70.5%) patients (Figure 1). CAD was the most frequent etiology, diagnosed in 72 (29.5%) subjects, of which 64 (88.9%) presented acute coronary syndromes. Non-ischemic structural heart disease and non-structural heart disease were identified in 62 (25.4%) and 38 (15.6%) patients, respectively. In the 30 to 40 year age group, CAD represented 40.9% of etiologies identified, and non-ischemic structural heart diseases were the main cause of SCA under 30 years (38.8%) (Figure 2).

Characteristics of CAD-Related SCA

Among CAD-related SCA cases, acute coronary syndromes were more frequent in younger patients (100.0% before 30 years, 87.7% between 30 and 40 years, and 76.3% after the age of 40-years, overall P=0.033), compared to chronic ischemic heart disease (without an acute culprit lesion) (Figure 2). Young CAD patients had more cardiovascular risk factors (≥1) than young non-CAD patients (84.3% vs. 50.5%, P<0.001), in particular current smoking (65.7% vs. 28.3%, P<0.001), dyslipidemia (14.5% vs. 1.0%, P=0.001) and family history of CAD (20.3% vs. 7.1%, P=0.03). These patients also had a different distribution of risk factors compared to older CAD cases, with a higher prevalence of active smoking (65.7% vs. 43.5%, P<0.001) and family history of CAD (20.3% vs. 9.3%, P=0.006), and a lower prevalence of other factors. Lastly, subjects with CAD-related SCA under 40 years less often had previously known heart disease (11.6%) compared to young non-CAD patients (37.0%) or older CAD-related cases (36.4%) (both P<0.001).

Early Coronary Intervention

Among all 409 patients younger than 40, 170 (41.7%) had immediate coronary angiography (vs. 65.1% in patients aged ≥ 40 years, P<0.001), and 50 (29.4%) of these patients underwent immediate PCI at admission (vs. 48.0% in patients aged ≥40 years, P<0.001). Additionally, among patients with a final diagnosis of acute coronary syndrome related to a culprit lesion, 7.8% did not undergo immediate coronary angiography (vs. 1.6% in older patients, P=0.007), and none of these patients presented with typical ST segment elevation on ECG. Compared to young patients not referred, those who underwent immediate coronary angiography were older (33.3±5.8 vs. 31.5±6.3 years, $P=0.003$), more frequently males (75.3% vs. 66.0%, $P=0.049$), a greater proportion had ST segment elevation (44.0% vs. 4.1%, $P<0.001$), and presented with better prognostic indicators (Table 2). During the study period, while the rate of immediate coronary angiography increased from 60.5% to 70.3% (P for trend <0.001) in patients aged ≥ 40 years, the rate in patients aged less than 40 years remained stable (43.5% to 45.3%, P for trend =0.795) (Figure 3). On multivariable analysis, patients younger than 40 years were significantly less likely to undergo immediate coronary angiography at hospital admission (OR=0.34, 95% CI: 0.25-0.47, $P<0.001$) (Table 3), although immediate coronary angiography was found to be significantly associated with survival at hospital discharge in these young patients (OR=2.68, 95% CI: 1.21-6.00, $P=0.015$).

Discussion

In this contemporary large population-based study, young SCA patients were significantly less likely to undergo immediate coronary angiography at hospital admission. However, CAD –especially acute coronary syndrome– was the main identified cause of SCA. Overall, our findings underline the lack of timely and systematic investigation of SCA in young adults admitted alive at hospital, suggesting an important missed opportunity for early intervention.

In the field of SCA, a threshold of 35 or 40 years is traditionally used to distinguish younger patients, in whom CAD is considered as less prevalent and in whom greater emphasis is usually laid on alternative diagnoses, in particular, inherited cardiomyopathies and electrical disorders (channelopathies)[11][12]. However, CAD epidemiology has changed over the last two decades, with an increase in CAD prevalence in the young population [13][14][15][16]. It has been shown recently that the rate of acute myocardial infarction is increasing in young patients [17], which might suggest a potential increase in the rate of CAD-related SCA among the youth.

Few systematic evaluations of SCA in the young have been conducted in the general population; most studies have only focused on particular subgroups, such as young competitive athletes [28]. However, underlying mechanisms and causes associated with SCA occurring during sports may be unique and not generalizable to all young SCA. While hypertrophic cardiomyopathy, myocarditis, arrhythmogenic right ventricular cardiomyopathy, or channelopathies have been considered for a long time to be the main etiologies underlying SCA during competitive sports, CAD has been shown to be an important cause when considering sports-related SCA in the general population (including recreational sports in the young) [29]. Outside the particular sports setting, data regarding CAD in young SCA victims is scarce. Our findings, however, reveal that CAD remains the single most common cause of SCA identified before the age of 40 years in the general population. These data from a population of SCA patients admitted alive to the hospital are consistent with the findings of a recent autopsy-based study of SCA [18].

Younger patients present more frequently with ST-segment elevation acute coronary syndrome (STEMI) [30], where ventricular fibrillation is more frequent than in non-ST elevation acute coronary events [31]. Although coronary plaque rupture determinants remain poorly elucidated, it may be hypothesized that shear forces induced by a greater degree of physical activity may provoke plaque fissuring and that the higher proportion of active smoking among younger patients could also predispose to plaque erosion and thrombosis, triggering ventricular arrhythmias [32]. Moreover, a higher risk of SCA during STEMI has been reported at a younger age, probably due to abrupt coronary artery occlusion in the absence of a developed collateral circulation as compared to older patients with chronic CAD [33].

Immediate coronary revascularization is associated with survival after resuscitated SCA [4][5][6][7][8]. In our study, patients younger than 40 years were less frequently subjected to an early invasive strategy. Moreover, a higher proportion of SCA actually due to an acute coronary syndrome (with an identified culprit lesion later) did not undergo immediate coronary angiography, when compared to older patients. While a recent study (in older populations) did not support immediate angiography in patients without ST-segment elevation [27], none of these patients had significant ECG changes, suggesting as already reported that the predictive value of the first recorded ECG in survivors of SCA is poor. Coronary lesions requiring PCI have been reported in nearly one-third of cases without initial ST segment elevation [34]. Although overall CAD-related SCA were more frequent in the elderly, the proportion of acute coronary syndromes was much higher among younger patients, compared to chronic CAD-related SCA. Most importantly, immediate coronary angiography was independently associated with improved survival at hospital discharge. These data suggest that CAD may be underappreciated as a cause of SCA in younger patients and support the consideration of prompt coronary angiography in young SCA patients as well, in the absence of another obvious cause.

The present study has several limitations, which need to be acknowledged. First, the number of patients < 40 years with a certain etiology is relatively modest. In most parts of the world, low autopsy rates in this setting constitute a considerable bottleneck in ascertaining definitive cause of SCA, and explain the relatively high proportion of cases without established diagnosis. Given this scenario, a systematic description of survivors represents the next best approach. SCA patients with a cause identified may not have the same distribution of causes compared with patients with undetermined cause or patients who do not survive the initial resuscitation attempt; however our data are consistent with a recent autopsy study of non-survivors [18], and the proportion of CAD among older patients in our population is congruent with the existing literature. Second, although our data are based on a large population with numerous centers involved, regional disparities may potentially exist and caution has to be exercised in generalizing these results. In particular, cardiovascular risk factor distribution may vary significantly between countries, for instance, smoking which is particularly prevalent in the young population in France [35]. Third, ascertaining causal relationship between SCA and CAD is sometimes difficult and debatable, particularly with chronic CAD-related SCA, in the absence of acute coronary occlusion. However, the majority of CAD-related SCA in young adults were due to acute coronary syndromes with identification of a culprit lesion. Lastly, the association identified between coronary angiography performance and survival at hospital discharge in young patients in our observational study cannot be interpreted as a causal relationship despite the multivariable analysis, due to possible confounding non-measured variables.

Conclusions

This population-based study demonstrates a low rate of immediate coronary angiography in young adults aged less than 40 years resuscitated from SCA, suggesting that CAD as a cause of SCA in this population may be underappreciated by the medical community. The high proportion of CAD in these patients, in particular acute coronary syndromes, underlines important missed opportunity for early intervention.

Conflict of interest

None.

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Figures legends

Figure 1. Causes of SCA in young adults

Details of SCA causes identified in 244 patients < 40 years admitted alive to hospital.

ARVC, Arrhythmogenic right ventricular cardiomyopathy; LVNC, left ventricle non-compaction; SADS, sudden arrhythmic death syndrome; SCA, sudden cardiac arrest; SUDS, sudden unexplained death syndrome; VF, ventricular fibrillation; WPW, Wolff-Parkinson-White

Figure 2. SCA etiologies identified by age groups (dark blue representing acute coronary syndrome and light blue chronic coronary artery disease).

Etiologies of SCA by age group (<30 years, 30-40 years, ≥40 years).

Figure 3. Evolution of the rate of immediate coronary angiography at hospital admission in patients ≥ 40 years (n = 3,170) compared with patients < 40 years (n = 409).

Tables

Table 1. General characteristics and resuscitation data of SCA admitted alive to hospital.

Sudden Cardiac Arrests	All n/3,579 (%)	18-40 y n/409 (%)	≥ 40 y n/3,170 (%)	p
Age (years±SD)	59.3±15.6	32.3±6.2	62.8±12.8	<0.001
Male gender	2,616 (73.1)	285 (69.7)	2,331 (73.5)	0.111
Prior known cardiac disease	1,099 (33.1)	59 (15.8)	1,040 (35.3)	<0.001
Coronary artery disease	592 (17.9)	4 (1.1)	588 (20.1)	<0.001
Non-ischemic heart disease	300 (8.5)	41 (10.1)	259 (8.3)	0.251
AF or flutter	338 (10.2)	6 (1.6)	332 (11.3)	<0.001
Pacemaker	89 (2.7)	4 (1.1)	85 (2.9)	0.040
Implantable cardioverter defibrillator	28 (0.8)	2 (0.5)	26 (0.9)	0.763
≥ 1 cardiovascular risk factor	2,715 (81.6)	202 (53.6)	2,513 (85.2)	<0.001
Hypertension	1,271 (38.3)	24 (6.4)	1,247 (42.4)	<0.001
Overweight (BMI > 25 kg/m2)	1,189 (35.6)	88 (23.2)	1,101 (37.2)	<0.001
Current smoking	1,128 (34.1)	134 (35.4)	994 (34.0)	0.641
Dyslipidemia	745 (22.5)	15 (4.0)	730 (24.9)	<0.001
Diabetes mellitus	583 (17.6)	8 (2.1)	575 (19.6)	<0.001
Family history of CAD	184 (5.6)	24 (6.4)	160 (5.5)	0.471
Chronic respiratory failure	215 (6.5)	4 (1.1)	211 (7.2)	<0.001
Chronic renal failure	178 (5.4)	7 (1.9)	171 (5.8)	0.001
Stroke	176 (5.3)	4 (1.1)	172 (5.9)	<0.001
Family history of SCA	84 (2.5)	30 (8.0)	54 (1.8)	<0.001
Sports-related	176 (5.0)	49 (12.2)	127 (4.1)	<0.001
Public place (vs home)	1,625 (45.5)	189 (46.2)	1,436 (45.4)	0.785
Witnessed SCA	3,262 (91.2)	367 (89.7)	2,895 (91.4)	0.319
Witnessed-CPR	2,347 (71.8)	271 (73.8)	2,076 (71.5)	0.383
Time from collapse to basic life support, median (IQR)	3.0 (0.0-8.3)	4.0 (0.0-10.0)	3.0 (0.0-8.0)	0.253
Time from EMS call to EMS arrival, median (IQR)	9.0 (7.0-12.0)	9.0 (7.0-12.0)	9.0 (7.0-12.0)	1
Initial shockable rhythm	1,905 (55.7)	231 (58.2)	1,674 (55.4)	0.314
Epinephrine use	2,149 (62.1)	264 (67.2)	1,885 (61.4)	0.030
ST segment elevation on first ECG	1,043 (33.1)	77 (23.5)	966 (34.2)	<0.001
Discharged alive	996 (27.9)	129 (31.6)	868 (27.4)	0.103
CPC score 1-2 at discharge	931 (26.0)	119 (29.1)	812 (25.6)	0.224

AF, atrial fibrillation; BMI, body mass index; CAD, coronary artery disease; CPR, cardiopulmonary resuscitation; ECG, electrocardiogram; EMS, emergency medical service; SCA, sudden cardiac arrest; SD, standard deviation

Table 2. Characteristics of young patients referred or not for immediate coronary angiography

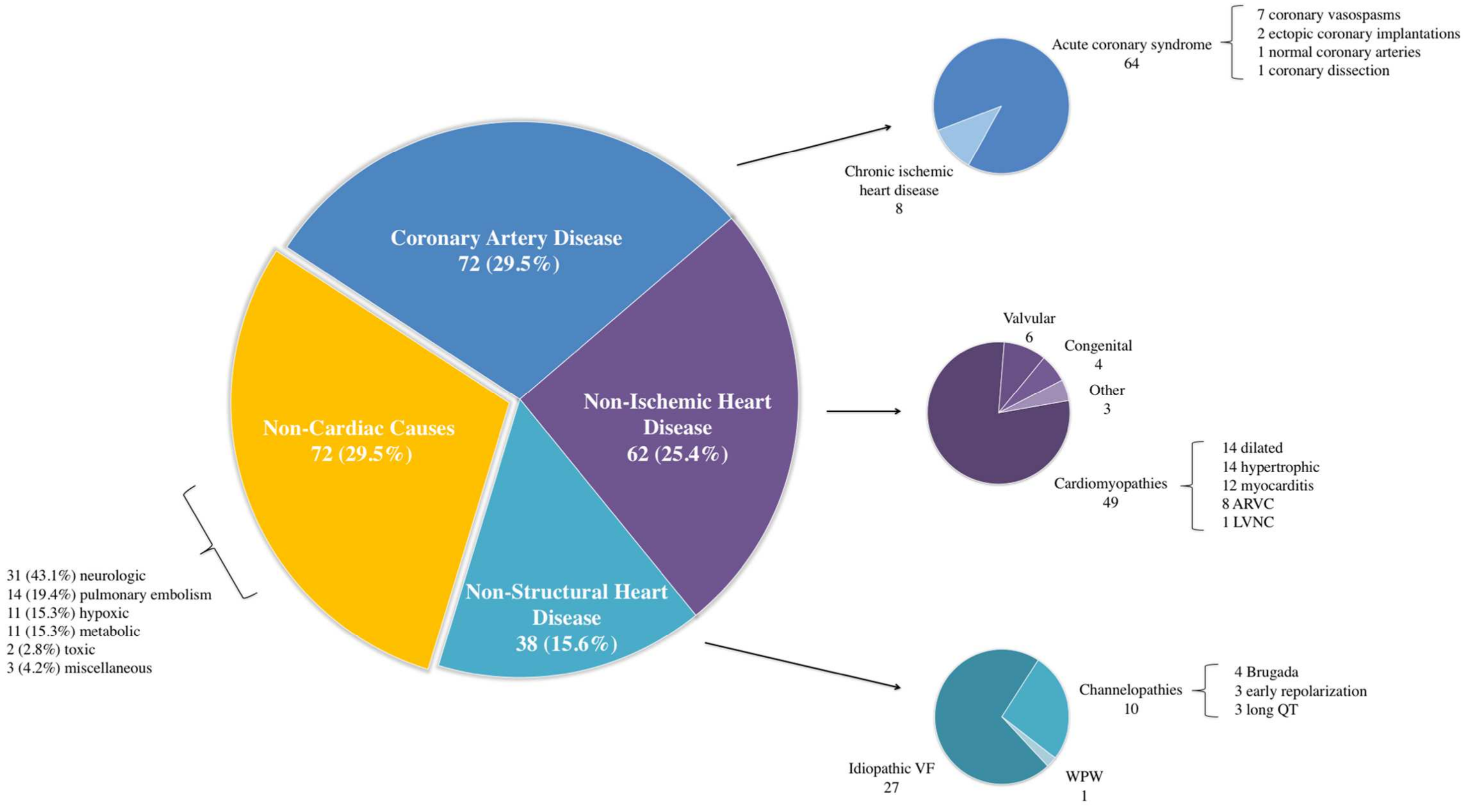
Sudden Cardiac Arrests	< 40 y Coronary angiography - n / 238 (%)	< 40 y Coronary angiography + n / 170 (%)	p
Age (years±SD)	31.5±6.3	33.3±5.8	0.003
Male gender	157 (66.0)	128 (75.3)	0.049
Sports-related	18 (7.7)	31 (18.5)	0.002
Public location	98 (41.2)	91 (53.5)	0.018
Witnessed SCA	208 (87.4)	158 (92.9)	0.098
Witnessed-CPR	141 (67.8)	130 (82.3)	0.003
Time from collapse to basic life support, median (IQR)	4.5 (0.0-10.0)	3.0 (0.0-7.0)	0.015
Time from EMS call to EMS arrival, median (IQR)	9.0 (7.0-12.0)	9.0 (7.0-11.0)	0.002
Initial shockable rhythm	95 (41.1)	135 (81.8)	<0.001
Epinephrine use	179 (77.8)	84 (51.9)	<0.001
ST segment elevation on first ECG	7 (4.1)	70 (44.0)	<0.001

CPR, cardiopulmonary resuscitation; ECG, electrocardiogram; EMS, emergency medical service; IQR: interquartile range; SCA, sudden cardiac arrest; SD: standard deviation

Table 3. Factors associated with immediate coronary angiography performance (among 3,579 SCA patients admitted alive at hospital).

	Univariate analysis		Multivariate analysis	
	OR (95% CI)	**p**	**OR (95% CI)**	**p**
Age, < 40 years	0.38 (0.31-0.47)	<0.001	0.34 (0.25-0.47)	<0.001
Male gender	1.91 (1.65-2.22)	<0.001	1.49 (1.18-1.87)	<0.001
Public location	1.74 (1.52-2.00)	<0.001	1.29 (1.04-1.60)	0.023
Witnessed SCA	1.89 (1.50-2.38)	<0.001	0.91 (0.19-4.79)	0.902
Witnessed-CPR	1.37 (1.17-1.61)	<0.001	1.28 (0.98-1.69)	0.075
Time from collapse to basic life support, > 3 min	0.87 (0.75-1.01)	0.055	1.31 (1.02-1.69)	0.038
Time from EMS call to EMS arrival, > 9 min	0.87 (0.75-0.99)	0.043	0.97 (0.78-1.19)	0.762
Initial shockable rhythm	5.19 (4.47-6.05)	<0.001	3.35 (2.70-4.17)	<0.001
Epinephrine use	0.34 (0.29-0.40)	<0.001	0.43 (0.34-0.54)	<0.001
ST segment elevation on first ECG	9.71 (7.72-12.37)	<0.001	7.14 (5.36-9.67)	<0.001

CI, confidence interval; CPR, cardiopulmonary resuscitation; ECG, electrocardiogram; EMS, emergency medical service; SCA, sudden cardiac arrest



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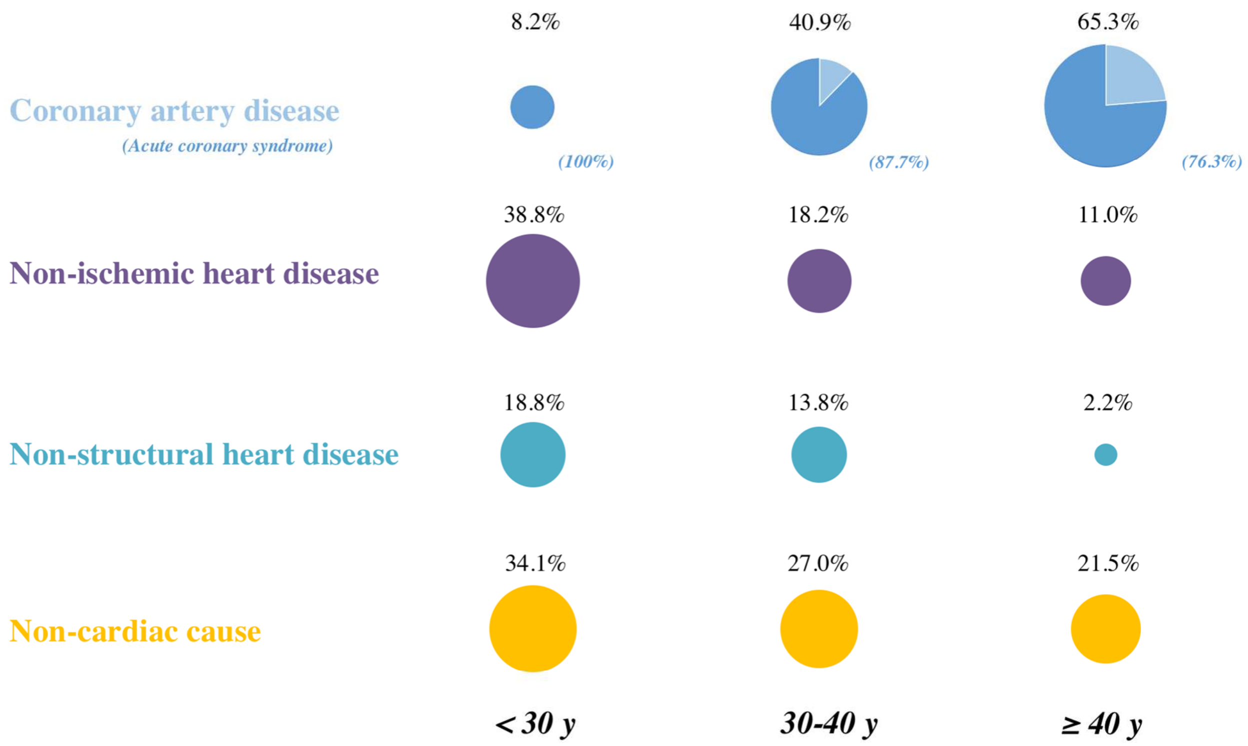

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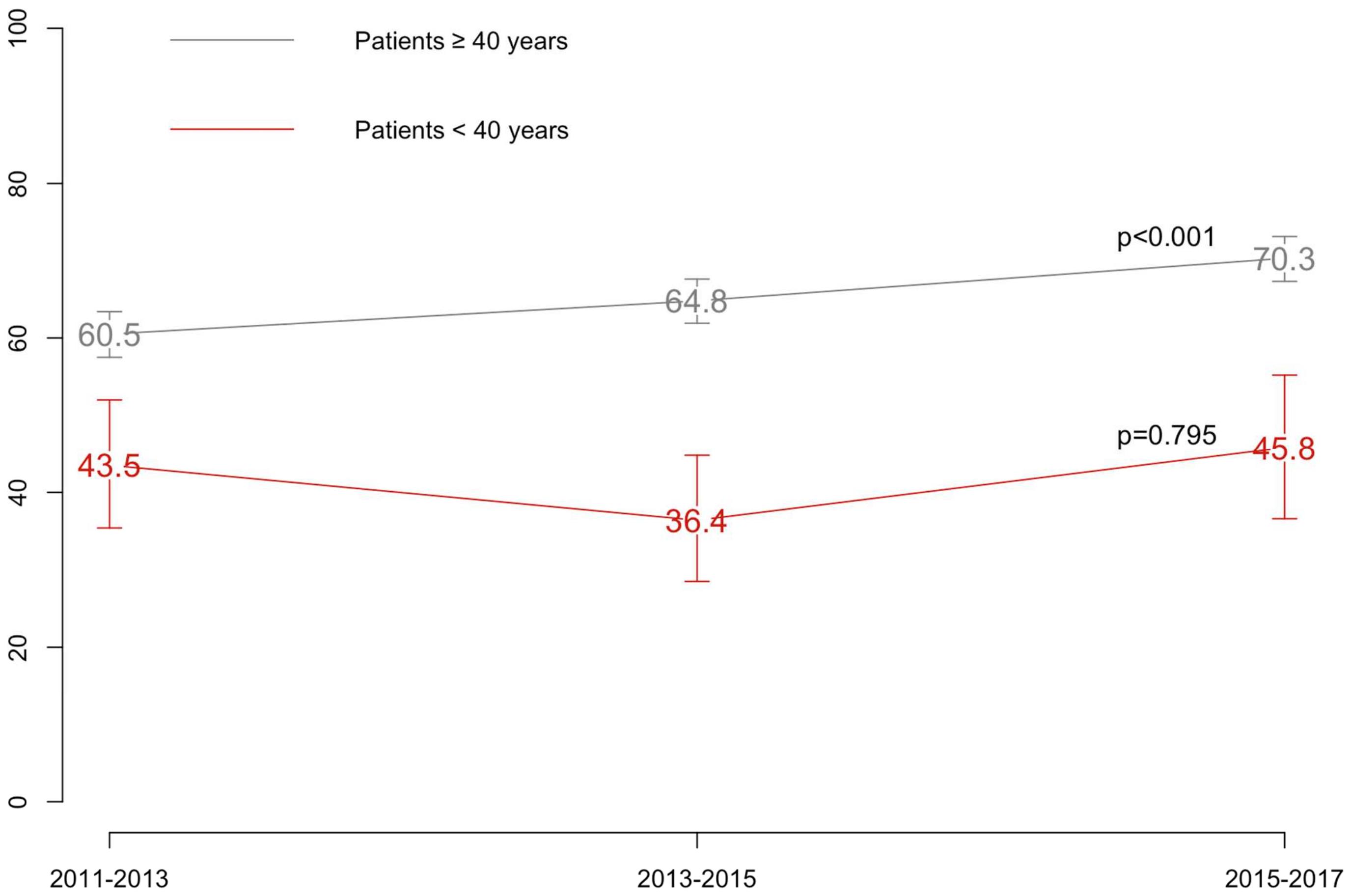

Figure 3. Evolution of the rate of immediate coronary angiography at hospital admission in patients ≥ 40 years (n = 3,170) compared with patients < 40 years (n = 409).

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