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1 **Low Rates of Immediate Coronary Angiography among Young Adults** 2 **Resuscitated From Sudden Cardiac Arrest**

3
4 Victor Waldmann^{1,2,3}, MD, MPH; Nicole Karam^{1,2,3}, MD, PhD; Julien Rischard^{1,2}, MD;
5 Wulfran Bougouin^{2,3,4}, MD, PhD; Ardalan Sharifzadehgan^{1,2,3}, MD, MPH; Florence
6 Dumas^{2,3,5}, MD, PhD; Kumar Narayanan^{2,6}, MD; Georgios Sideris⁷, MD, PhD; Sebastian
7 Voicu⁸, MD; Estelle Gandjbakhch^{9,10}, MD, PhD; Daniel Jost¹¹, MD; Lionel Lamhaut¹², MD,
8 PhD; Bertrand Ludes¹³, MD; Isabelle Plu¹⁴, MD; Frankie Beganton², MS; Karim Wahbi^{3,15},
9 MD; Olivier Varenne^{3,15}, MD, PhD; Bruno Megarbane⁸, MD, PhD; Vincent Algalarrondo^{10,16},
10 MD, PhD; Fabrice Extramiana^{10,16}, MD, PhD; Nicolas Lellouche^{10,17}, MD; David S.
11 Celermajer¹⁸, MBBS, FRACP; Christian Spaulding^{1,3}, MD, PhD; Antoine Lafont^{1,3}, MD,
12 PhD; Alain Cariou^{2,3,19}, MD, PhD; Xavier Jouven^{1,2,3*}, MD, PhD; Eloi Marijon^{1,2,3,10*}, MD,
13 PhD – On Behalf Paris-SDEC investigators

14
15 ¹ AP-HP, European Georges Pompidou Hospital, Cardiology Department, Paris, France

16 ² Sudden Death Expertise Center, INSERM U970, Paris Cardiovascular Research Center (PARCC),
17 European Georges Pompidou Hospital, Paris, France

18 ³ Paris University, Paris, France

19 ⁴ Ramsay Générale de Santé, Hôpital privé Jacques Cartier, Intensive Care Unit, Massy, France

20 ⁵ AP-HP, Cochin-Hotel Hospital, Emergency Department, Paris, France

21 ⁶ Maxcure Hospitals, Hyderabad, India

22 ⁷ AP-HP, Lariboisière Hospital, Cardiology Department, Paris, France

23 ⁸ AP-HP, Lariboisière Hospital, Intensive Care Unit, Paris, France

24 ⁹ AP-HP, La Pitié Salpêtrière University Hospital, Cardiology Department, Paris, France

25 ¹⁰ Groupe Parisien Universitaire de Rythmologie (G.P.U.R.)

26 ¹¹ Paris Firefighters Brigade, Paris, France

27 ¹² AP-HP, SAMU de Paris, Necker Hospital, Paris, France

28 ¹³ Forensic Medical Institute, Paris, France

29 ¹⁴ AP-HP, La Pitié Salpêtrière University Hospital, Anatomopathology Department, Paris, France

30 ¹⁵ AP-HP, Cochin Hospital, Cardiology Department, Paris, France

31 ¹⁶ AP-HP, Bichat-Claude-Bernard Hospital, Cardiology Department, Paris, France

32 ¹⁷ AP-HP, Henri Mondor Hospital, Cardiology Department, Créteil, France

33 ¹⁸ Faculty of Medicine and Health, Sydney, Australia

34 ¹⁹ AP-HP, Cochin Hospital, Intensive Care Unit, Paris, France

35

36 *Equally contributed to the manuscript

37

38 **Corresponding author**

39 Eloi Marijon MD, PhD

40 Hôpital européen Georges Pompidou

41 Département de Cardiologie

42 20-40 Rue Leblanc 75908 Paris Cedex 15, France

43 Phone: +33662833848

44 Fax : +33156093047

45 Email: eloi.marijon@aphp.fr

46

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1 **Abstract (250 w)**

2 **Aim**

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

6 **Methods**

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

11 **Results**

12 Out of 3,579 SCA admitted alive, 409 (11.4%) patients were under 40 years of age (32.3±6.2
13 years, 69.7% males), with 244 patients having a definite cause identified. Among those, CAD
14 accounted for 72 (29.5%) cases, of which 64 (88.9%) were acute coronary syndromes. The
15 rate of immediate coronary angiography was only 41.7% compared to 65.1% among those ≥
16 40-years (P<0.001). During the study period, while the rate of immediate coronary
17 angiography increased from 60.5% to 70.3% (P <0.001) in patients aged ≥ 40 years, the rate
18 in patients aged less than 40 years remained stable (43.5% to 45.3%, P =0.795). Patients
19 younger than 40 years were significantly less likely to undergo immediate coronary
20 angiography (OR=0.34, 95% CI: 0.25-0.47), although early angiography was associated with
21 survival at hospital discharge (OR=2.68, 95% CI: 1.21-6.00).

22 **Conclusion**

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

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

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1 **Introduction**

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

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

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

23

24 **Methods**

25 *Study setting*

1 The Paris-Sudden Death Expertise Center (SDEC) registry is an ongoing study which has
2 been described previously [20][21][22][23][24]. Briefly, it is a comprehensive, prospective
3 population-based registry comprising Paris and suburbs, encompassing a residential
4 population of 6.7 million (approximately 10% of the total French population) and covering
5 762 km². In Paris, management of out-of-hospital cardiac arrest involves mobile emergency
6 units (Service d'Aide Médicale Urgente), and firefighters (Brigade de Sapeurs Pompiers de
7 Paris), with at least one trained emergency physician on board. Patients in whom a return of
8 spontaneous circulation is achieved are then referred to a center with an intensive care unit
9 (ICU) and coronary intervention facilities. Owing to a close collaboration with all the pre-
10 hospital Emergency Medical Services (EMS), 48 hospitals, and forensic units, every case of
11 out-of-hospital cardiac arrest aged ≥ 18 years occurring in the area is systematically enrolled
12 in the SDEC registry, since May 2011. Exclusion criteria include age less than 18 years and
13 cardiac arrest occurring outside the geographical area of interest. Regular external audits on
14 the registry have shown that 99 % of cardiac arrest cases admitted alive to the hospital were
15 detected [20].

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

21 ***Study population***

22 All SCA admitted alive to hospital were included from 15 May 2011 to 15 May 2017.

23 According to definitions from the last consensus, SCA was defined as an unexpected out-of-
24 hospital cardiac arrest without obvious non-cardiac cause, occurring with a rapid witnessed
25 collapse within 1 hour after the onset of symptoms, or if unwitnessed, within the 24 hours

1 after the last contact [1]. Those likely due to non-cardiac circumstances (such as trauma,
2 drowning, hanging etc.) or prior terminal condition were not included. The present study
3 specifically focused on young adults aged less than 40 years old.

4 ***Data collection***

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

1 ***Definitions***

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

13 ***Statistical analysis***

14 Continuous data were reported as mean \pm standard deviation (SD) or median and interquartile
15 range (IQR) for normally and non-normally distributed data respectively. Categorical data
16 were reported as numbers and percentages. Comparisons used the χ^2 or Fisher's exact test for
17 categorical variables and Student's t test or Mann–Whitney–Wilcoxon test, when appropriate,
18 for continuous variables. Multiple logistic regressions were used (i) to compare the rate of
19 immediate coronary angiography at hospital admission according to patient's age, and (ii) to
20 assess the association between immediate coronary angiography performance and survival
21 rate at hospital discharge. The main known pre-hospital outcome predictors were included as
22 explicative variables in the former model (age, gender, location of SCA, witness presence and
23 witness-cardiopulmonary resuscitation, delays from collapse to basic life support and from
24 call for EMS to arrival of EMS, presence of a shockable rhythm, epinephrine use), as well as
25 ST segment elevation on first recorded ECG. Main comorbidities were also included in the

1 second model. Variables significantly associated ($P < 0.20$) in univariate analysis were
2 assessed in multivariate logistic regression. Linear time trends analysis on the rate of
3 immediate coronary angiography were tested with the use of logistic regression dividing this
4 6-year study in 3 periods of 24 months. Missing data on study variables were no more than
5 10%, except for ST segment elevation on first ECG (12.0%) and interval from collapse to
6 basic life support (12.3%), and were handled using case-complete analysis. Results were
7 considered statistically significant at $P < 0.05$. All analyses were two-tailed. Statistical
8 analysis was performed using R software, version 3.3.2 (R Project for Statistical Computing).

9

10 **Results**

11 *Population*

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

22 *Causes of SCA among the Young*

23 Among young SCA patients, the cause was uncertain in 165 (40.3%) cases due to early death
24 and negative or incomplete initial work-up in ICU. Among 244 young adults with a definite
25 etiology identified, a non-cardiac cause was diagnosed in 72 (29.5%) patients, and a cardiac

1 cause was identified in 172 (70.5%) patients (Figure 1). CAD was the most frequent etiology,
2 diagnosed in 72 (29.5%) subjects, of which 64 (88.9%) presented acute coronary syndromes.
3 Non-ischemic structural heart disease and non-structural heart disease were identified in 62
4 (25.4%) and 38 (15.6%) patients, respectively. In the 30 to 40 year age group, CAD
5 represented 40.9% of etiologies identified, and non-ischemic structural heart diseases were
6 the main cause of SCA under 30 years (38.8%) (Figure 2).

7 ***Characteristics of CAD-Related SCA***

8 Among CAD-related SCA cases, acute coronary syndromes were more frequent in younger
9 patients (100.0% before 30 years, 87.7% between 30 and 40 years, and 76.3% after the age of
10 40-years, overall $P=0.033$), compared to chronic ischemic heart disease (without an acute
11 culprit lesion) (Figure 2). Young CAD patients had more cardiovascular risk factors (≥ 1) than
12 young non-CAD patients (84.3% vs. 50.5%, $P<0.001$), in particular current smoking (65.7%
13 vs. 28.3%, $P<0.001$), dyslipidemia (14.5% vs. 1.0%, $P=0.001$) and family history of CAD
14 (20.3% vs. 7.1%, $P=0.03$). These patients also had a different distribution of risk factors
15 compared to older CAD cases, with a higher prevalence of active smoking (65.7% vs. 43.5%,
16 $P<0.001$) and family history of CAD (20.3% vs. 9.3%, $P=0.006$), and a lower prevalence of
17 other factors. Lastly, subjects with CAD-related SCA under 40 years less often had previously
18 known heart disease (11.6%) compared to young non-CAD patients (37.0%) or older CAD-
19 related cases (36.4%) (both $P<0.001$).

20 ***Early Coronary Intervention***

21 Among all 409 patients younger than 40, 170 (41.7%) had immediate coronary angiography
22 (vs. 65.1% in patients aged ≥ 40 years, $P<0.001$), and 50 (29.4%) of these patients underwent
23 immediate PCI at admission (vs. 48.0% in patients aged ≥ 40 years, $P<0.001$). Additionally,
24 among patients with a final diagnosis of acute coronary syndrome related to a culprit lesion,
25 7.8% did not undergo immediate coronary angiography (vs. 1.6% in older patients, $P=0.007$),

1 and none of these patients presented with typical ST segment elevation on ECG. Compared to
2 young patients not referred, those who underwent immediate coronary angiography were
3 older (33.3 ± 5.8 vs. 31.5 ± 6.3 years, $P=0.003$), more frequently males (75.3% vs. 66.0% ,
4 $P=0.049$), a greater proportion had ST segment elevation (44.0% vs. 4.1% , $P < 0.001$), and
5 presented with better prognostic indicators (Table 2). During the study period, while the rate
6 of immediate coronary angiography increased from 60.5% to 70.3% (P for trend < 0.001) in
7 patients aged ≥ 40 years, the rate in patients aged less than 40 years remained stable (43.5% to
8 45.3% , P for trend $= 0.795$) (Figure 3). On multivariable analysis, patients younger than 40
9 years were significantly less likely to undergo immediate coronary angiography at hospital
10 admission ($OR=0.34$, 95% CI: $0.25-0.47$, $P < 0.001$) (Table 3), although immediate coronary
11 angiography was found to be significantly associated with survival at hospital discharge in
12 these young patients ($OR=2.68$, 95% CI: $1.21-6.00$, $P=0.015$).

13

14 **Discussion**

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

20 In the field of SCA, a threshold of 35 or 40 years is traditionally used to distinguish
21 younger patients, in whom CAD is considered as less prevalent and in whom greater
22 emphasis is usually laid on alternative diagnoses, in particular, inherited cardiomyopathies
23 and electrical disorders (channelopathies)[11][12]. However, CAD epidemiology has changed
24 over the last two decades, with an increase in CAD prevalence in the young population
25 [13][14][15][16]. It has been shown recently that the rate of acute myocardial infarction is

1 increasing in young patients [17], which might suggest a potential increase in the rate of
2 CAD-related SCA among the youth.

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

16 Younger patients present more frequently with ST-segment elevation acute coronary
17 syndrome (STEMI) [30], where ventricular fibrillation is more frequent than in non-ST
18 elevation acute coronary events [31]. Although coronary plaque rupture determinants remain
19 poorly elucidated, it may be hypothesized that shear forces induced by a greater degree of
20 physical activity may provoke plaque fissuring and that the higher proportion of active
21 smoking among younger patients could also predispose to plaque erosion and thrombosis,
22 triggering ventricular arrhythmias [32]. Moreover, a higher risk of SCA during STEMI has
23 been reported at a younger age, probably due to abrupt coronary artery occlusion in the
24 absence of a developed collateral circulation as compared to older patients with chronic CAD
25 [33].

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

17 The present study has several limitations, which need to be acknowledged. First, the
18 number of patients < 40 years with a certain etiology is relatively modest. In most parts of the
19 world, low autopsy rates in this setting constitute a considerable bottleneck in ascertaining
20 definitive cause of SCA, and explain the relatively high proportion of cases without
21 established diagnosis. Given this scenario, a systematic description of survivors represents the
22 next best approach. SCA patients with a cause identified may not have the same distribution
23 of causes compared with patients with undetermined cause or patients who do not survive the
24 initial resuscitation attempt; however our data are consistent with a recent autopsy study of
25 non-survivors [18], and the proportion of CAD among older patients in our population is

1 congruent with the existing literature. Second, although our data are based on a large
2 population with numerous centers involved, regional disparities may potentially exist and
3 caution has to be exercised in generalizing these results. In particular, cardiovascular risk
4 factor distribution may vary significantly between countries, for instance, smoking which is
5 particularly prevalent in the young population in France [35]. Third, ascertaining causal
6 relationship between SCA and CAD is sometimes difficult and debatable, particularly with
7 chronic CAD-related SCA, in the absence of acute coronary occlusion. However, the majority
8 of CAD-related SCA in young adults were due to acute coronary syndromes with
9 identification of a culprit lesion. Lastly, the association identified between coronary
10 angiography performance and survival at hospital discharge in young patients in our
11 observational study cannot be interpreted as a causal relationship despite the multivariable
12 analysis, due to possible confounding non-measured variables.

13

14 **Conclusions**

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

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2 **Conflict of interest**

3 None.

4

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9

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16

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1 **Figures legends**

2

3 **Figure 1.** Causes of SCA in young adults

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

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

8

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

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

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13 **Figure 3.** Evolution of the rate of immediate coronary angiography at hospital admission in patients
14 ≥ 40 years (n = 3,170) compared with patients < 40 years (n = 409).

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1 **Tables**

2

3 **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/m ²) | 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 |

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5 *AF, atrial fibrillation; BMI, body mass index; CAD, coronary artery disease; CPR,*

6 *cardiopulmonary resuscitation; ECG, electrocardiogram; EMS, emergency medical service;*

7 *SCA, sudden cardiac arrest; SD, standard deviation*

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2 **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 |

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5 *CPR, cardiopulmonary resuscitation; ECG, electrocardiogram; EMS, emergency medical service;*6 *IQR: interquartile range; SCA, sudden cardiac arrest; SD: standard deviation*

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1 **Table 3.** Factors associated with immediate coronary angiography performance (among 3,579
 2 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 |

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

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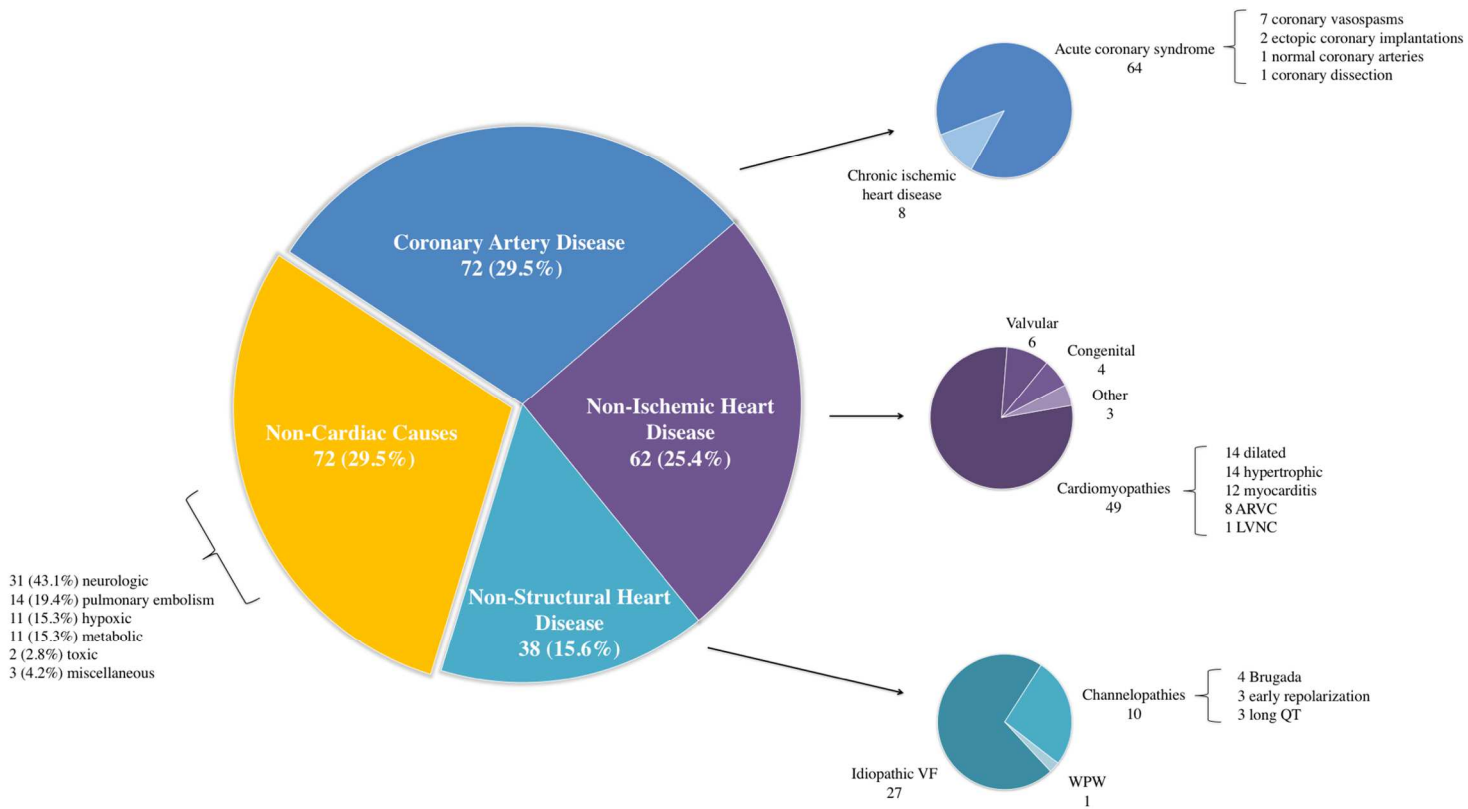
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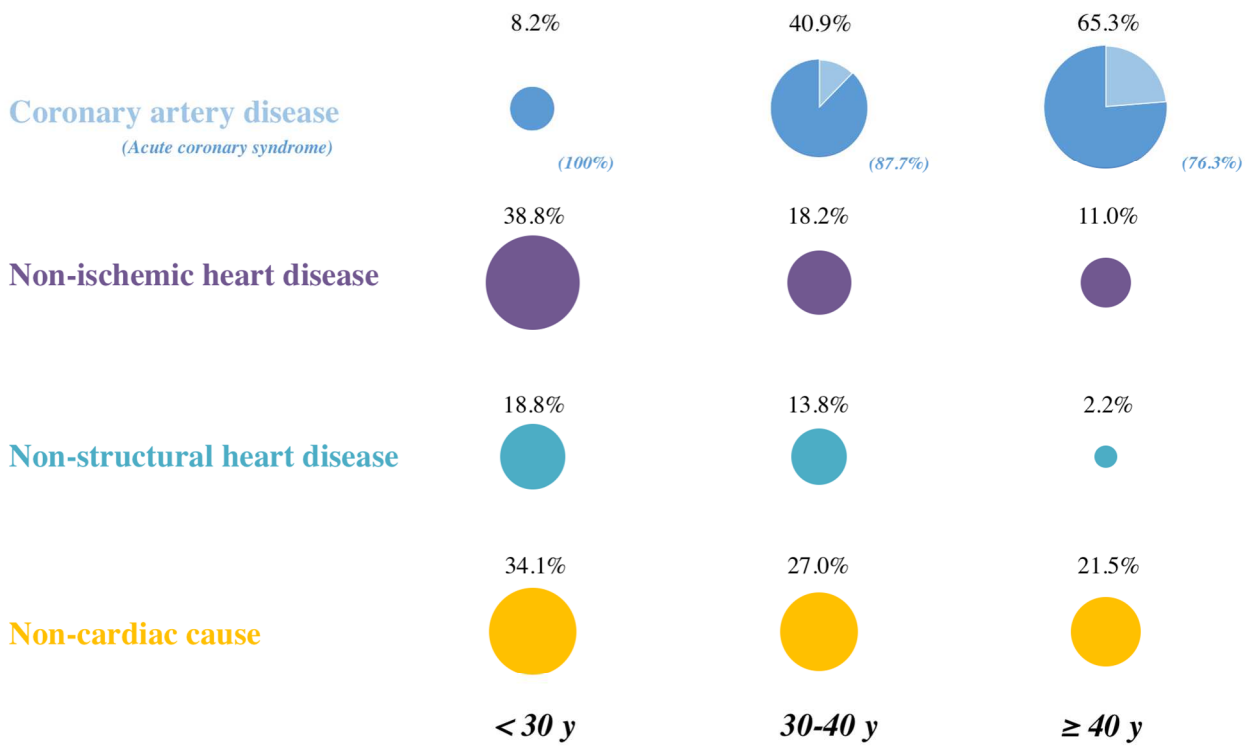
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3 **Figure 1.** Causes of SCA in young adults

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

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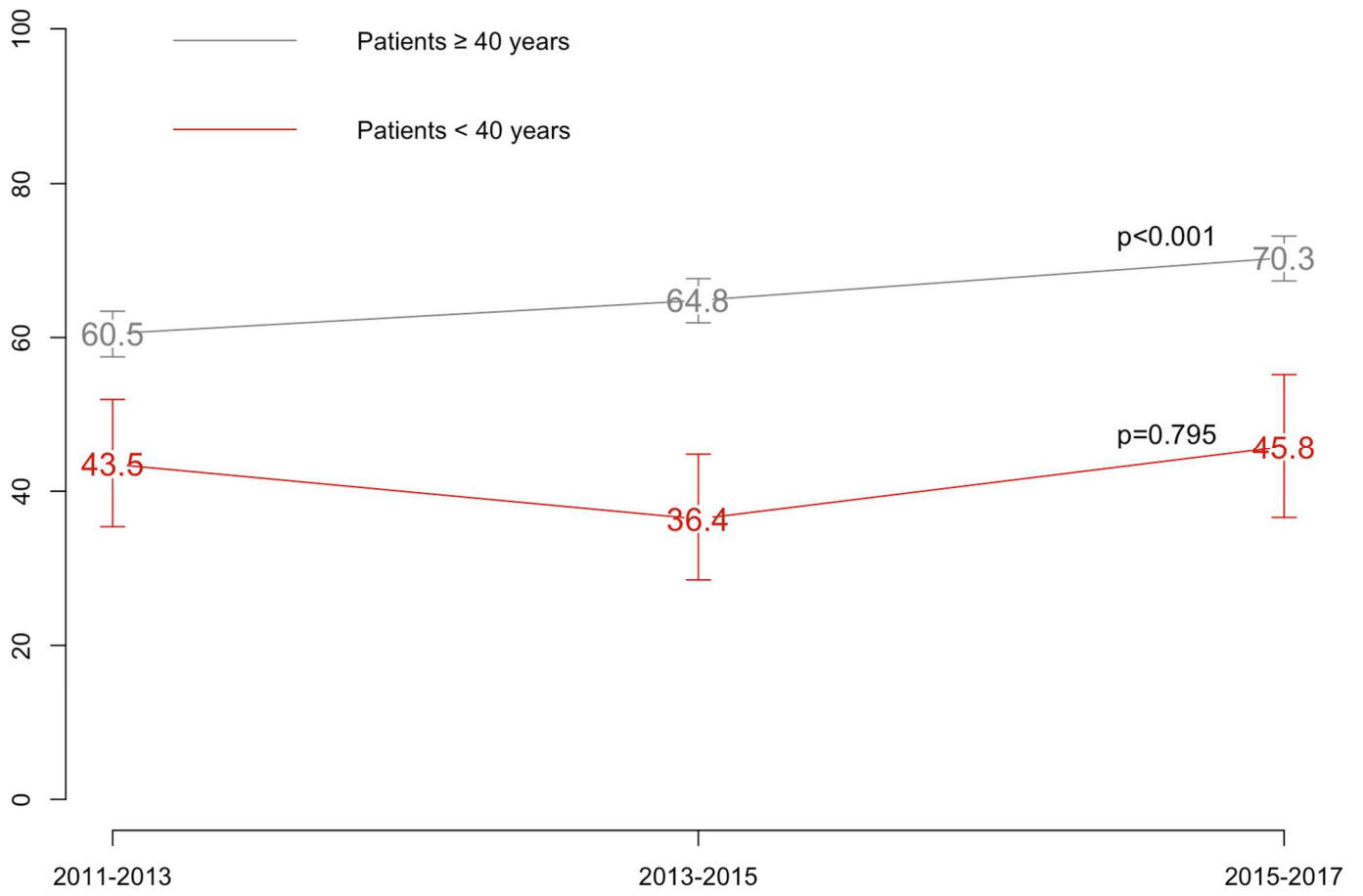


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6 **Figure 2.** SCA etiologies identified by age groups (dark blue representing acute coronary syndrome
7 and light blue chronic coronary artery disease).

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5 **Figure 3.** Evolution of the rate of immediate coronary angiography at hospital admission in patients

6 ≥ 40 years (n = 3,170) compared with patients < 40 years (n = 409).

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Data Supplement– List of Paris-Sudden Death Expertise Center Investigators

- 1
2
- 3 **Adnet F**, AP-HP, Paris 13 University, Avicenne Hospital, Emergency Medical Services
4 (SAMU) 93, Bobigny, France
- 5 **Agostinucci JM**, AP-HP, Paris 13 University, Avicenne Hospital, Emergency Medical
6 Services (SAMU) 93, Bobigny, France
- 7 **Aissaoui-Balanant N**, AP-HP, Georges Pompidou European Hospital, Medical Intensive
8 Care Unit, Paris, France
- 9 **Algalarrondo V**, AP-HP, Antoine Beclere University Hospital, Department of Cardiology,
10 Clamart, France
- 11 **Alla F**, French National Health Insurance (CNAMTS), Paris, France
- 12 **Alonso C**, Clinique Ambroise Paré, Department of Cardiology, Neuilly, France
- 13 **Amara W**, Hospital Group of Montfermeil – Le Raincy, Department of Cardiology,
14 Montfermeil, France
- 15 **Annane D**, AP-HP, INSERM U1173 (Laboratory of Inflammation and Infection), University
16 of Versailles - Saint Quentin en Yvelines, Raymond Poincare Hospital, General
17 Intensive Care Unit, Garches, France
- 18 **Antoine C**, Biomedecine agency, Saint-Denis-la-Plaine, France
- 19 **Aubry P**, AP-HP, Bichat Hospital, Department of Cardiology, Paris, France
- 20 **Azoulay E**, AP-HP, Paris Diderot Sorbonne University, Saint Louis Hospital, Medical
21 Intensive Care Unit, Paris, France
- 22 **Beganton F**, INSERM U970 - PARCC, Paris, France
- 23 **Benhamou D**, AP-HP, Bicetre Hospital, Department of Anaesthesia and Intensive Care
24 Medicine, Le Kremlin-Bicetre, France
- 25 **Billon C**, AP-HP, Georges Pompidou European Hospital, Department of Genetic, Paris,
26 France
- 27 **Bougouin W**, INSERM U970 - PARCC, Paris, France
- 28 **Boutet J**, AP-HP, Raymond Poincare Hospital, Emergency Medical Services (SAMU) 92,
29 Garches, France
- 30 **Bruel C**, Saint Joseph Hospital, Medical-Surgical Intensive Care Unit, Paris, France
- 31 **Bruneval P**, AP-HP, Georges Pompidou European Hospital, Pathology Department, Paris,
32 France
- 33 **Cariou A**, AP-HP, Cochin Hospital, Medical Intensive Care Unit, Paris, France
- 34 **Carli P**, AP-HP, Paris Descartes University, Necker - Enfants Malades Hospital, Emergency
35 Medical Services (SAMU) 75, Intensive Care Unit, Paris, France
- 36 **Casalino E**, AP-HP, Emergency Medical Services (SAMU) 92, Clichy, France
- 37 **Cerf C**, Foch Hospital, Intensive Care Unit, Suresnes, France
- 38 **Chaib A**, Andre Gregoire Hospital, Department of Cardiology, Montreuil, France
- 39 **Cholley B**, AP-HP, Georges Pompidou European Hospital, Department of Anaesthesia and
40 Surgical Intensive Care Medicine, Paris, France
- 41 **Cohen Y**, AP-HP, Avicenne Hospital, Medical-Surgical Intensive Care Unit, Bobigny,
42 France
- 43 **Combes A**, AP-HP, Pitié-Salpetriere Hospital, Cardiology Institute (ICAN), Intensive Care
44 Unit, Paris, France
- 45 **Crahes M**, AP-HP, Georges Pompidou European Hospital, Pathology Department, Paris,
46 France
- 47 **Da Silva D**, Delafontaine Hospital, Intensive Care Unit, Saint-Denis, France
- 48 **Das V**, Andre Gregoire Hospital, Medical-Surgical Intensive Care Unit, Montreuil, France

1 **Demoule A**, AP-HP, Pitie Salpetriere Hospital, Medical Intensive Care Unit and Respiratory
2 Division, Paris, France
3 **Denjoy I**, AP-HP, Bichat Hospital, Department of Cardiology, Paris, France
4 **Deye N**, AP-HP, Lariboisiere Hospital, Intensive Care Unit, Paris, France
5 **Dhonneur G**, AP-HP, Henri Mondor Hospital, Department of Anaesthesia and Surgical
6 Intensive Care Medicine, Creteil, France
7 **Diehl JL**, AP-HP, Georges Pompidou European Hospital, Medical Intensive Care Unit, Paris,
8 France
9 **Dinanian S**, AP-HP, Antoine Beclere Hospital, Department of Cardiology, Clamart, France
10 **Domanski L**, Brigade de Sapeurs Pompiers de Paris (BSPP), Paris, France
11 **Dreyfuss D**, AP-HP, Louis Mourier Hospital, Intensive Care Unit, Colombes, France
12 **Duboc D**, AP-HP, Cochin Hospital, Department of Cardiology, Paris, France
13 **Dubois-Rande JL**, AP-HP, Henri Mondor Hospital, Department of Cardiology, Creteil,
14 France
15 **Dumas F**, AP-HP, Cochin Hospital, Department of Emergency, Paris, France
16 **Empana JP**, INSERM U970 - PARCC, Paris, France
17 **Extramiana F**, AP-HP, Bichat Hospital, Department of Cardiology, Paris, France
18 **Fartoukh M**, AP-HP, Sorbonne University (Paris 6), Tenon Hospital, Intensive Care Unit,
19 Paris, France
20 **Fioux F**, CHI Montfermeil, Intensive Care Unit, France
21 **Gabbas M**, French National Health Insurance (CNAMTS), Paris, France
22 **Gandjbakhch E**, AP-HP, Pitie-Salpetriere Hospital, Cardiology Institute (ICAN),
23 Department of Cardiology, Paris, France
24 **Geri G**, AP-HP, Ambroise Pare Hospital, Intensive Care Unit, Boulogne-Billancourt, France
25 **Guidet B**, AP-HP, Sorbonne University (Pierre et Marie Curie University – Paris 6), Saint
26 Antoine Hospital, Intensive Care Unit, Paris, France
27 **Halimi F**, Private Hospital of Parly 2, Department of Cardiology, Le Chesnay, France
28 **Henry P**, AP-HP, Sorbonne Paris Cite University (Paris Diderot University), Lariboisiere
29 Hospital, Department of Cardiology, Paris, France
30 **Hidden Lucet F**, AP-HP, Pitie-Salpetriere Hospital, Cardiology Institute (ICAN),
31 Department of Cardiology, Paris, France
32 **Jabre P**, INSERM U970 – PARCC, Emergency Medical Services (SAMU) 75, Paris, France
33 **Jacob L**, AP-HP, Saint Louis Hospital, Department of Anaesthesia and Surgical Intensive
34 Care Medicine, Paris, France
35 **Joseph L**, Bicetre Hospital, Transplant Coordination, Le Kremlin-Bicetre, France
36 **Jost D**, Brigade de Sapeurs Pompiers de Paris (BSPP), Paris, France
37 **Jouven X**, AP-HP, Georges Pompidou European Hospital, Department of Cardiology, Paris,
38 France
39 **Karam N**, AP-HP, Georges Pompidou European Hospital, Department of Cardiology, Paris,
40 France
41 **Kassim H**, INSERM U970 - PARCC, Paris, France
42 **Lacotte J**, Private Hospital Jacques Cartier, Department of Cardiology, Massy, France
43 **Lahlou-Laforet K**, AP-HP, Georges Pompidou European Hospital, Department of
44 Psychiatry, Paris, France
45 **Lamhaut L**, AP-HP, Paris Descartes University, Necker - Enfants Malades Hospital,
46 Emergency Medical Services (SAMU) 75, Intensive Care Unit, Paris, France
47 **Lanceleur A**, Foch Hospital, Intensive Care Unit, Suresnes, France
48 **Langeron O**, AP-HP, Pitie-Salpetriere Hospital, Department of Anaesthesia and Surgical
49 Intensive Care Medicine, Paris, France

1 **Lavergne T**, AP-HP, Georges Pompidou European Hospital, Department of Cardiology,
2 Paris, France
3 **Lecarpentier E**, AP-HP, Henri Mondor Hospital, Emergency Medical Services (SAMU) 94,
4 Creteil, France
5 **Leenhardt A**, AP-HP, Bichat Hospital, Department of Cardiology, Paris, France
6 **Lellouche N**, AP-HP, Henri Mondor Hospital, Department of Cardiology, Creteil, France
7 **Lemiale V**, AP-HP, Paris Diderot University, Saint Louis Hospital, Medical Intensive Care
8 Unit, Paris, France
9 **Lemoine F**, Brigade de Sapeurs Pompiers de Paris (BSPP), Paris, France
10 **Linval F**, AP-HP, Paris 13 University, Avicenne Hospital, Emergency Medical Services
11 (SAMU) 93, Bobigny, France
12 **Loeb T**, AP-HP, Raymond Poincare Hospital, Emergency Medical Services (SAMU) 92,
13 Garches, France
14 **Ludes B**, Institute of Legal Medicine, Paris Descartes University, Paris, France
15 **Luyt CE**, AP-HP, Pitie-Salpetriere Hospital, Cardiology Institute (ICAN), Intensive Care
16 Unit, Paris, France
17 **Maltret A**, AP-HP, Necker - Enfants Malades Hospital, Department of Pediatric Cardiology,
18 Paris, France
19 **Mansencal N**, Ambroise Pare Hospital, Department of Cardiology, Boulogne-Billancourt,
20 France
21 **Mansouri N**, AP-HP, Henri Mondor Hospital, Emergency Medical Services (SAMU) 94,
22 Creteil, France
23 **Marijon E**, AP-HP, Georges Pompidou European Hospital, Department of Cardiology, Paris,
24 France
25 **Marty J**, AP-HP, Henri Mondor Hospital, Emergency Medical Services (SAMU) 94, Creteil,
26 France
27 **Maury E**, AP-HP, Sorbonne University (Pierre et Marie Curie University – Paris 6), Saint
28 Antoine Hospital, Intensive Care Unit, Paris, France
29 **Maxime V**, AP-HP, Raymond Poincare Hospital, General Intensive Care Unit, Garches,
30 France
31 **Megarbane B**, AP-HP, Lariboisiere Hospital, Intensive Care Unit, Paris, France
32 **Mekontso-Dessap A**, AP-HP, DHU A-TVVB, CARMAS Research Group, Henri Mondor
33 Hospital, Intensive Care Unit, Creteil, France
34 **Mira JP**, AP-HP, Cochin Hospital, Medical Intensive Care Unit, Paris, France
35 **Monnet X**, AP-HP, Bicetre Hospital, Medical Intensive Care Unit, Le Kremlin-Bicetre,
36 France
37 **Narayanan K**, INSERM U970 - PARCC, Paris, France
38 **Ngoyi N**, AP-HP, Paris 7 University, Beaujon Hospital, Emergency Medical Services
39 (SAMU) 92, Clichy, France
40 **Perier MC**, INSERM U970 - PARCC, Paris, France
41 **Piot O**, Centre Cardiologique du Nord, Department of Cardiology, Saint-Denis, France
42 **Pirracchio R**, AP-HP, Georges Pompidou European Hospital, Intensive Care Unit, Paris,
43 France
44 **Plaisance P**, Emergency Medical Services (SAMU) 75, Lariboisière SMUR, Paris, France
45 **Plu I**, AP-HP, Pitie-Salpetriere Hospital, Neuropathology Escourolle, Paris, France
46 **Raux M**, AP-HP, Pitié Salpêtrière Hospital, Department of Anesthesiology and Critical Care,
47 Paris, France
48 **Revaux F**, AP-HP, Henri Mondor Hospital, Emergency Medical Services (SAMU) 94,
49 Creteil, France
50 **Ricard JD**, AP-HP, Louis Mourier Hospital, Intensive Care Unit, Colombes, France

1 **Richard C**, AP-HP, Bicetre Hospital, Medical Intensive Care Unit, Le Kremlin-Bicetre,
2 France
3 **Riou B**, AP-HP, Pitie-Salpetriere Hospital, Sorbonne University (Pierre et Marie Curie
4 University – Paris 6), Department of Emergency Medicine and Surgery, Paris,
5 France
6 **Roussin F**, AP-HP, Saint Louis Hospital, Department of Anaesthesia and Surgical Intensive
7 Care Medicine, Paris, France
8 **Santoli F**, Robert Ballanger Hospital, Intensive Care Unit, Aulnay-sous-Bois, France
9 **Schortgen F**, Centre Hospitalier Intercommunal Créteil, Intensive Care Unit, Creteil, France
10 **Sharifzadehgan A**, AP-HP, Georges Pompidou European Hospital, Department of
11 Cardiology, Paris, France
12 **Sideris G**, AP-HP, Sorbonne Paris Cite University (Paris Diderot University), Lariboisiere
13 Hospital, Department of Cardiology, Paris, France
14 **Spaulding C**, AP-HP, Georges Pompidou European Hospital, Department of Cardiology,
15 Paris, France
16 **Teboul JL**, AP-HP, Bicetre Hospital, Medical Intensive Care Unit, Le Kremlin-Bicetre,
17 France
18 **Timsit JF**, AP-HP, Bichat Hospital, Medical Intensive Care Unit, Paris, France
19 **Tourtier JP**, Brigade de Sapeurs Pompiers de Paris (BSPP), Paris, France
20 **Tuppin P**, French National Health Insurance (CNAMTS), Paris, France
21 **Ursat C**, AP-HP, Raymond Poincare Hospital, Emergency Medical Services (SAMU) 92,
22 Garches, France
23 **Varenne O**, AP-HP, Cochin Hospital, Department of Cardiology, Paris, France
24 **Veillard-Baron A**, AP-HP, Ambroise Pare Hospital, Intensive Care Unit, Boulogne-
25 Billancourt, France
26 **Voicu S**, AP-HP, Lariboisiere Hospital, Intensive Care Unit, Paris, France
27 **Wahbi K**, AP-HP, Cochin Hospital, Department of Cardiology, Paris, France
28 **Waldmann V**, AP-HP, Georges Pompidou European Hospital, Department of Cardiology,
29 Paris, France
30
31
32