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ORIGINAL STUDIES

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EDITORIAL COMMENT: Expert Article Analysis for:
Postponing cardiac procedures during the pandemic: The balance between elective and selective!

Consequences of canceling elective invasive cardiac procedures during Covid-19 outbreak

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Abbreviations: ACI-SEC, Asociación de Cardiología Intervencionista de la Sociedad Española de Cardiología; ASD, atrial septal defect; CCS, Canadian Society of Cardiology; CAD, coronary artery disease; COVID, coronavirus disease; ISCHEMIA, International Study of Comparative Health Effectiveness with Medical and Invasive Approaches; LAAC, left atrial appendage closure; NYHA, New York Heart Association; PARTNER, patients undergoing transcatheter aortic valve replacement, insight form the placement of aortic transcatheter valve; PCI, percutaneous coronary intervention; SARS-Cov-2, Severe Acute Respiratory Syndrome Coronavirus 2; TAVI, transcatheter aortic valve implantation.

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Abstract

Background: During COVID-19 pandemic in Spain, elective procedures were canceled or postponed, mainly due to health care systems overwhelming.

Objective: The objective of this study was to evaluate the consequences of interrupting invasive procedures in patients with chronic cardiac diseases due to the COVID-19 outbreak in Spain.

Methods: The study population is comprised of 2,158 patients that were pending on elective cardiac invasive procedures in 37 hospitals in Spain on the 14th of March 2020, when a state of alarm and subsequent lockdown was declared in Spain due to the COVID-19 pandemic. These patients were followed-up until April 31th.

Results: Out of the 2,158 patients, 36 (1.7%) died. Mortality was significantly higher in patients pending on structural procedures (4.5% vs. 0.8%, respectively; $p < .001$), in those >80 year-old (5.1% vs. 0.7%, $p < .001$), and in presence of diabetes (2.7% vs. 0.9%, $p = .001$), hypertension (2.0% vs. 0.6%, $p = .014$), hypercholesterolemia (2.0% vs. 0.9%, $p = .026$) [Correction added on December 23, 2020, after first online publication: as per Dr. Moreno's request changes in p-values were made after original publication in Abstract.], chronic renal failure (6.0% vs. 1.2%, $p < .001$), NYHA > II (3.8% vs. 1.2%, $p = .001$), and CCS > II (4.2% vs. 1.4%, $p = .013$), whereas was it was significantly lower in smokers (0.5% vs. 1.9%, $p = .013$). Multivariable analysis identified age > 80, diabetes, renal failure and CCS > II as independent predictors for mortality.

Conclusion: Mortality at 45 days during COVID-19 outbreak in patients with chronic cardiovascular diseases included in a waiting list due to cancellation of invasive elective procedures was 1.7%. Some clinical characteristics may be of help in patient selection for being promptly treated when similar situations happen in the future.

KEYWORDS

catheterization, diagnostic, percutaneous coronary intervention (PCI), transcatheter valve implantation (TVI)

1 | INTRODUCTION

During the first months of 2020, a SARS-CoV-2 pandemic affected the whole world,[1] with millions of patients developing COVID-19 disease, and more than 1 million deaths due to the infection by November 2020.[2] Health care systems were severely overwhelmed, affecting cardiovascular patient care. Because of that, and also to reduce the risk of virus contamination, most elective invasive procedures were canceled or postponed and also some indications for non-elective procedures were modified.

Spain has been one of the most severely affected countries in terms of the number of patients with the infection and the number of deaths per million inhabitants. The Spanish association of interventional cardiology (ACI-SEC) recommended to maintain an invasive management as the default strategy to treat patients with acute coronary syndromes[3,4] but to postpone elective procedures.[3] Accordingly, the number of stable patients being attended in the catheterization laboratories dramatically decreased.[5]

Consequently, a high number of patients scheduled to diagnostic and/or therapeutic invasive cardiac procedures in the catheterization laboratories were included in a waiting list, until the pandemic was controlled or at least the hospitals recovered the capacity of treating and admitting elective patients.

The objective of this study, that was initiated by the ACI-SEC, was to evaluate the consequences (mainly in terms of mortality) of interrupting invasive treatment for patients with chronic cardiac diseases due to the COVID-19 outbreak in Spain, as well as to know what patients are at higher risk of dying while waiting for the procedure. The final purpose was to identify what patients should be candidates for not postponing or canceling the procedure in future outbreaks by the SARS-CoV2 or other infective agents.

2 | METHODS

2.1 | Study period and selection of patients

Due to the COVID-19 pandemic, a state of alarm was declared in Spain on the 14th of March 2020.[6] As a consequence, the majority of units of interventional cardiology canceled or postponed elective procedures, to reserve hospital beds for COVID-19 patients, and to prevent contamination by the SARS-CoV2 virus in cardiovascular patients.[3,4]

The study population is comprised of those non hospitalized patients that were pending on elective diagnostic and/or therapeutic procedures on the 14th of March 2020 in Spain.

2.2 | Data collection and follow-up

Data were entered in an electronic database (pInvestiga, Moaña, Pontevedra, Spain). Clinical variables, such as main cardiovascular disease pending on treatment, type of procedure pending to be performed, clinical situation, and cardiovascular risk factors, were collected.

All patients were followed up to the 31th of April 2020 (45 days). The primary endpoint was death. Secondary endpoints included cardiovascular death, the need for an urgent procedure due to clinical unstabilization, and the incidence of COVID-19 disease.

2.3 | Definitions

Coronary angiography and/or PCI as the type of pending procedure included coronary angiography in patients with previously diagnosed or suspected CAD, and those with previously known CAD pending on PCI (e.g., stage procedures). Coronary angiography to rule out CAD as the underlying cause of left ventricular dysfunction was also included in this category. However, coronary angiography as part of the study of patients pending on any type of surgical intervention was included in a different category, because the main underlying condition was considered to be the disorder pending to be treated (e.g., valvular heart disease) rather than the eventual bystander of coronary artery disease. Other procedures included transcatheter aortic valve implantation, percutaneous mitral valve repair, percutaneous closure of left atrial appendage, percutaneous closure of ASD, or percutaneous treatment of tricuspid regurgitation.

2.4 | Statistical analysis

Continuous variables are presented as mean ± *SD*, and compared using the Student *t*-test or appropriate nonparametric tests. Discrete variables are presented as percentages (proportions), and compared with the Chi-square test, using Fisher correction when needed. Statistical analysis was done using the SPSS statistical package (Chicago, Illinois). Associations were considered statistically significant when

$p < .05$, although all p values are presented. Univariable and multivariable analysis were conducted in order to identify independent risk factors for mortality, and for secondary endpoints.

3 | RESULTS

3.1 | Study population

Overall, 2,158 patients were included in 37 hospitals. Clinical characteristics of the study population are shown in Table 1.

The main underlying disease was CAD (50.0%), aortic stenosis (25.1%), and mitral valve disease (7.3%). Other conditions included left ventricular dysfunction (5.9%), ASD (2.7%), pulmonary hypertension (2.5%), atrial fibrillation (2.4%), aortic regurgitation (1.9%), other congenital cardiac diseases (1.5%), tricuspid regurgitation (0.5%), and ventricular arrhythmia (0.3%).

TABLE 1 Characteristics of the study population

Age (year-old)	69.9 ± 11.9
Age > 80	23.0
Female gender	37.7
Diabetes	32.7
Hypertension	67.3
Hypercholesterolemia	55.6
Smoking	29.9
Chronic renal failure	9.2
Peripheral artery disease	10.5
Previous CAD	32.4
Previous infarction	13.6
Previous PCI	18.3
Previous CABG	4.4
Previous surgical valve replacement	4.5
Left ventricular dysfunction	23.3
Main underlying disease	
CAD	50.0
Valvular heart disease	34.8
Aortic stenosis	25.1
Aortic regurgitation	1.9
Mitral valve disease	7.3
Tricuspid regurgitation	0.5
Pulmonary valve disease	0.1
Left ventricular dysfunction	5.9
Congenital cardiac diseases	4.1
ASD	2.7
Other congenital cardiac diseases	1.4
Pulmonary hypertension	2.5
Arrhytmia	2.6
Atrial fibrillation	2.4
Ventricular arrhytmia	0.3

The pending technique was coronary angiography and/or PCI (53.2%), cardiac catheterization in patients scheduled for cardiac surgery (12.4%), TAVI (15.2%), other diagnostic procedures (9.3%), LAAC (3.1%), percutaneous closure of ASD (2.4%), percutaneous mitral valve repair (1.2%), and other therapeutic procedures (3.3%).

3.2 | Mortality and cardiovascular mortality: Incidence and predictive factors

Out of the 2,158 patients, 36 (1.7%) died. The cause of death was considered cardiac in 24 (67.7%) and noncardiac in 12 (33.3%). Thus, cardiovascular and noncardiovascular mortality rate was 1.1%, and 0.6%, respectively.

In comparison with patients pending on diagnostic or therapeutic coronary procedures, those pending on structural procedures had significantly higher all-cause (4.5% vs. 0.8%, respectively; $p < .001$), and cardiovascular (2.7% vs. 0.5%, respectively; $p < .001$) mortality rates. Among patients pending on structural interventions, mortality was especially high in those pending on percutaneous mitral valve repair (8.0%), TAVI (4.9%) and LAAC (4.5%), whereas there were no deaths among those pending on percutaneous closure of ASD, or other therapeutic techniques. Cardiovascular mortality was particularly high among patients pending on TAVI (3.1%), and LAAC (1.5%), whereas no cardiovascular mortality occurred among patients pending on other structural procedures, including percutaneous repair of mitral regurgitation.

Patients who died were significantly older (age 80.4 ± 7.1 vs. 69.7 ± 11.9 in those who survived; $p < .001$), and had more frequency of diabetes, hypertension, hypercholesterolemia, and renal failure (Table 2). Conversely, the mortality rate was lower in smokers. Cardiovascular mortality was significantly higher in patients >80, female gender, diabetes, hypertension and chronic renal failure, but lower in smokers (Table 2). Both mortality and cardiovascular mortality rates were significantly associated with functional class, including NYHA and CCS (Figure 1a,b).

Among the 682 patients with previously known CAD, 263 (38.6%), 356 (52.2%), and 63 (9.2%) had single-vessel, multi-vessel and left main disease, respectively. The mortality rate was 1.5%, 1.7%, and 4.8%, in those groups, respectively ($p = .075$). Cardiovascular mortality was 1.0%, 0.8%, and 3.2%, respectively ($p = .105$).

In the multivariable analysis, age > 80, chronic renal failure, diabetes, and CCS > II were independent predictors of mortality (Figure 2a). For cardiovascular mortality, the independent predictors in the multivariable analysis were chronic renal failure, age > 80, diabetes, and female gender (Figure 2b).

3.3 | Patients undergoing an urgent procedure due to clinical unstabilization

The procedure was performed urgently due to clinical unstabilization in 180 patients (8.3%). This was more frequent among patients pending on diagnostic procedures and/or PCI than for structural interventions (9.3% vs. 5.2%, respectively; $p = .005$). The procedure was

TABLE 2 Mortality and cardiovascular mortality rates in different subgroups of patients

	Overall mortality			CV mortality		
	Yes	No	P value	Yes	No	*p* value
Age > 80	5.1	0.7	<.001	2.8	0.3	<.001
Female gender	2.4	1.3	.057	1.6	0.4	.005
Diabetes	2.7	0.9	.001	1.9	0.4	<.001
Hypertension	2.0	0.6	.014	1.2	0.1	.014
Hypercholesterolemia	2.0	0.9	.026	1.2	0.4	.057
Smoking	0.5	1.9	.013	0.2	1.1	.030
Chronic renal failure	6.0	1.2	<.001	4.5	0.5	<.001
Peripheral artery disease	3.1	1.5	.094	0.0	1.0	.251
Previous CAD	2.1	1.3	.213	0.9	0.9	.942
Previous infarction	1.4	1.7	.810	0.7	0.9	1.000
Previous PCI	1.3	1.8	.490	1.0	0.9	.765
Previous CABG	3.2	1.6	.205	1.1	0.9	.573
Previous valve replacement	2.2	1.4	.392	1,1	0.8	.543
Left ventricular dysfunction	1.0	1.7	.836	0.8	0.9	.900
NYHA > II	3.8	1.2	.001	2.4	0.7	.017
CCS > II	4.2	1.4	.013	3.0	0.8	<.001
Structural procedure	4.5	0.8	<.001	2.3	0.5	.001

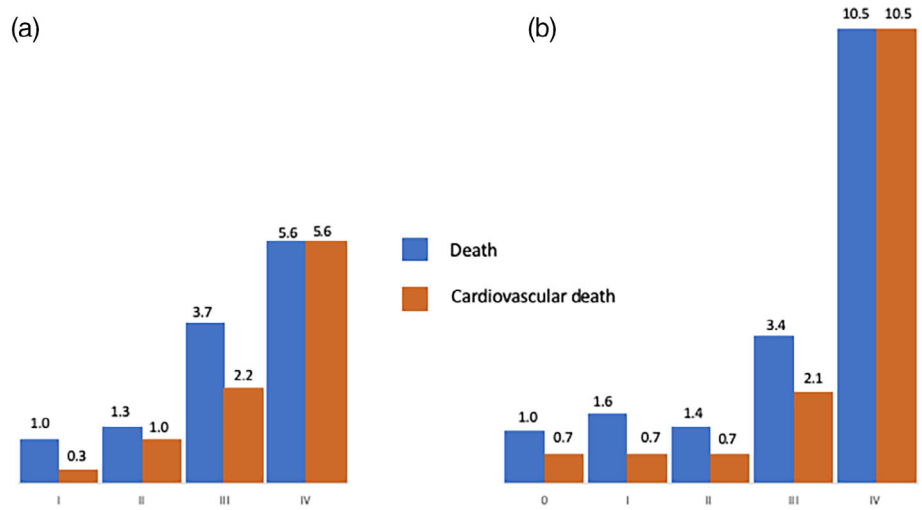

FIGURE 1 Mortality and cardiovascular mortality accordingly to the NYHA (a) and CCS (b) class [Color figure can be viewed at wileyonlinelibrary.com]

performed in 7.1% and 3.0% of patients pending on TAVI and LAAC, respectively, whereas no patients pending on percutaneous repair of mitral regurgitation or percutaneous closure of ASD underwent the procedure during the study period. Patients in whom the procedure was performed urgently were more frequent >80, and had a higher prevalence of diabetes, hypercholesterolemia, peripheral artery disease, previous PCI, NYHA > II, and CCS > II (Table 3). A non-structural intervention as pending procedure, NYHA > II, age > 80, and CCS > II were independently associated with the need of an urgent procedure (Figure 3a).

Out of the 2,158 patients, 212 (9.8%) died or needed an urgent procedure. This was more frequent among patients with age > 80, diabetes, hypertension, hypercholesterolemia, peripheral artery disease, NYHA > II and CCS > II, and less frequent in smokers (Table 3). In the multivariable analysis, CCS > II, age > 80, NYHA > II, peripheral artery disease, and diabetes were independent risk factors for death or the need for urgent procedure (Figure 3b).

3.4 | COVID-19 disease among patients on waiting list

Among the 2,158 patients, 37 (1.7%) had confirmed COVID-19 disease, 11 of whom (29.8%) died. The incidence of COVID-19 disease was 12.0%, 3.9%, 3.0%, 2.1%, 1.5%, 1.1%, 1.0%, and 1.4% in patients pending on percutaneous repair of mitral regurgitation, percutaneous

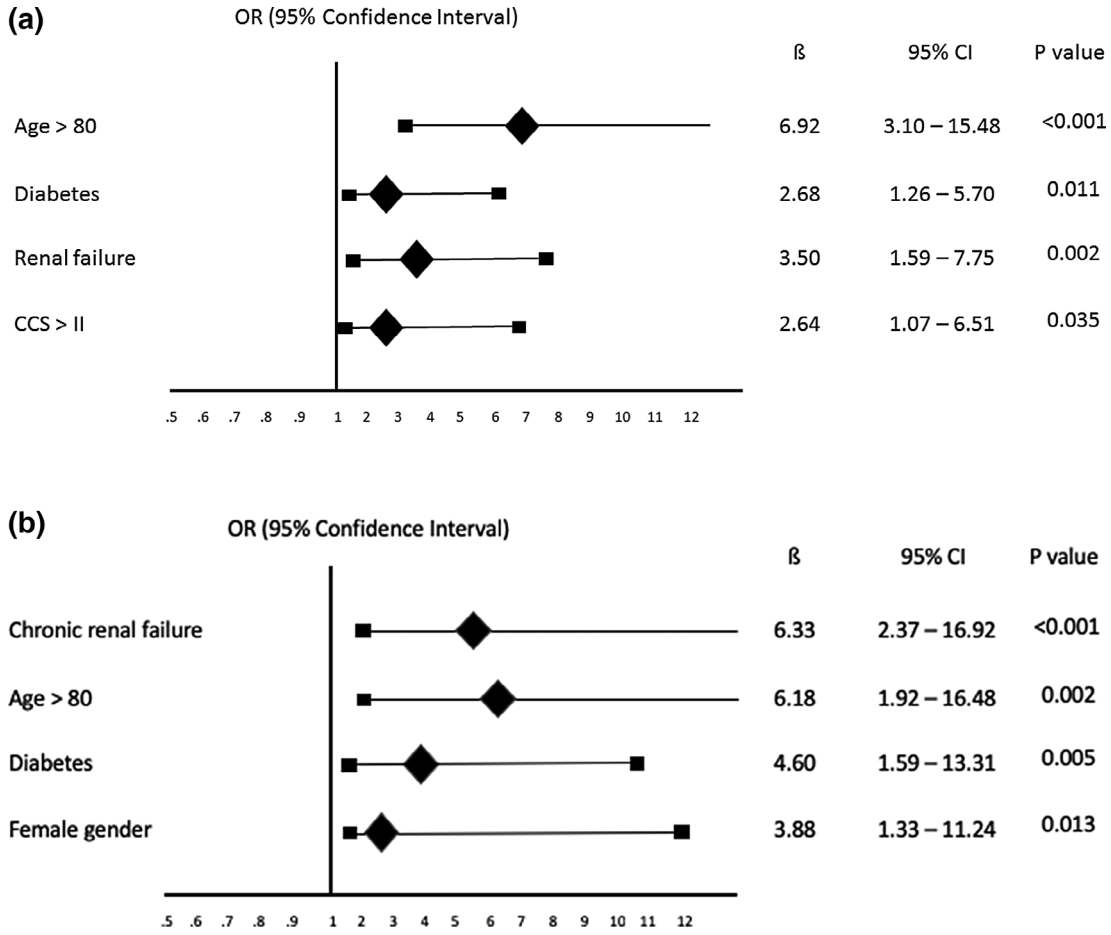

FIGURE 2 Independent predictors for mortality (a) and cardiovascular mortality (b)

	Urgent procedure			Mortality or urgent procedure		
	Yes	No	P value	Yes	No	*p* value
Age > 80	10.7	7.6	.028	15.0	8.3	<.001
Female gender	8.3	8.4	.943	9.4	10.5	.417
Diabetes	10.6	7.5	.002	13.2	8.2	<.001
Hypertension	9.1	7.4	.198	10.8	7.8	.031
Hypercholesterolemia	9.8	6.9	.019	11.6	7.7	.003
Smoking	7.0	9.1	.114	7.5	10.8	.022
Chronic renal failure	8.0	8.4	.872	13.1	9.5	.107
Peripheral artery disease	12.8	7.8	.011	15.9	9.1	.001
Previous CAD	9.5	7.9	.215	11.4	9.0	.084
Previous infarction	7.5	8.5	.579	8.9	10.0	.557
Previous PCI	10.9	7.8	.043	12.2	9.3	.085
Previous CABG	7.4	8.4	.748	9.6	9.8	.934
Previous valve replacement	5.5	8.7	.290	7.7	9.9	.489
Left ventricular dysfunction	10.2	7.8	.138	10.7	9.4	.354
NYHA > II	12.6	7.4	.002	15.6	8.6	<.001
CCS > II	15.2	7.9	.001	18.8	9.1	<.001
Structural procedure	5.2	9.3	.005	9.2	10.0	.591

TABLE 3 Characteristics associated with the need for urgently performing the pending procedure

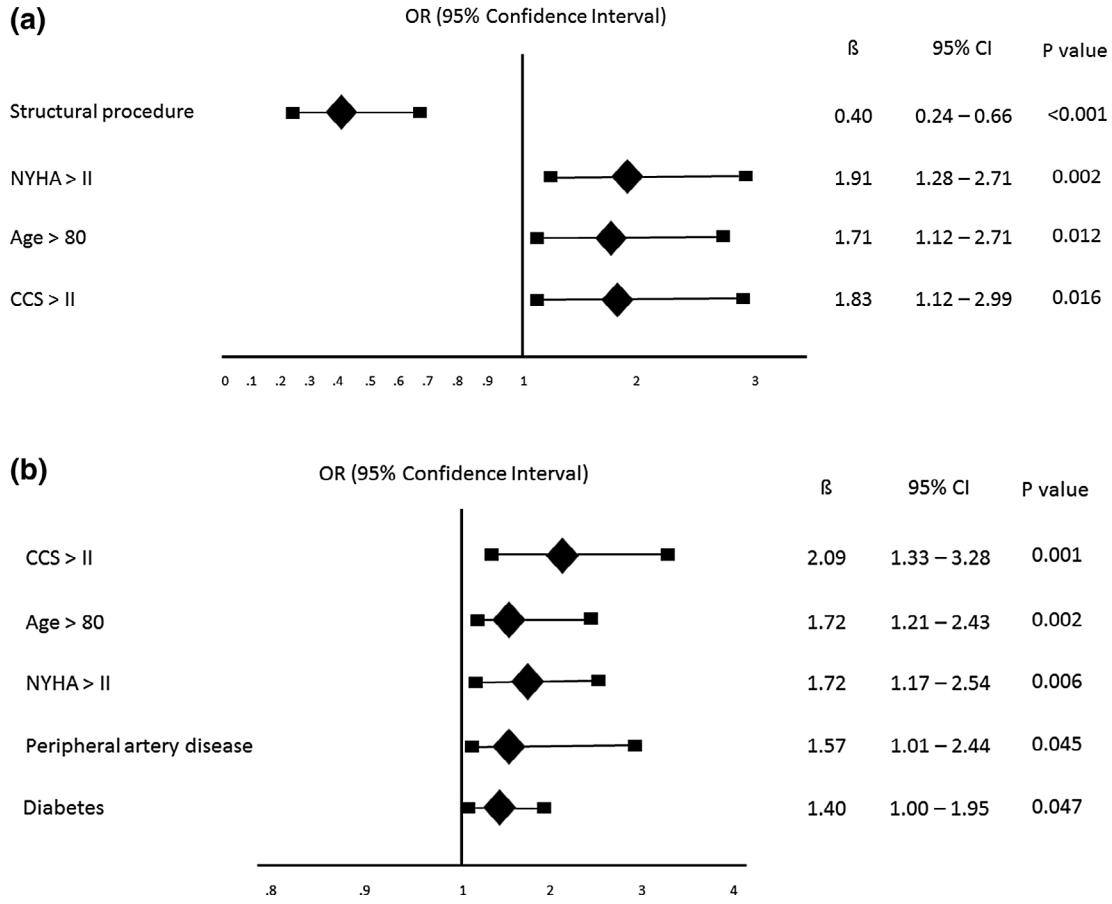

FIGURE 3 Independent predictors of the need for an urgent procedure (a) or the combination of death or urgent procedure (b)

closure of ASD, LAAC, TAVI, coronary procedures (diagnostic or therapeutic), coronary angiography before surgical intervention, and other therapeutic procedures, respectively.

In the univariable analysis, characteristics associated with a higher risk of COVID-19 disease were age > 80, previous CAD, chronic renal failure, peripheral artery disease, and structural intervention as pending procedure (Table 4). In the multivariable analysis, age > 80, previous CAD, chronic renal failure, peripheral artery disease were independent predictors of COVID-19 disease (Figure 4).

Among patients with known CAD, the incidence of COVID-19 disease was 3.0%, 2.5%, and 3.2% in those with single-vessel, multivessel, and left main disease, respectively (p = .689).

TABLE 4 Characteristics associated with COVID-19 infection

	Yes	No	*p* value
Age > 80	3.2	1.3	.003
Female gender	1.6	1.8	.762
Diabetes	2.0	1.4	.291
Hypertension	1.6	1.6	.971
Hypercholesterolemia	1.9	1.3	.281
Smoking	1.0	1.8	.138
Chronic renal failure	4.5	1.4	.001
Peripheral artery disease	5.3	1.3	<.001
Previous CAD	3.1	0.9	<.001
Previous infarction	2.0	1.7	.636
Previous PCI	2.3	1.6	.339
Previous CABG	2.1	1.7	.752
Previous valve replacement	1.1	1.6	,685
Left ventricular dysfunction	1.0	1.8	.545
NYHA >2	2.6	1.5	.146
CCS > 2	2.4	1.6	.423
Structural procedure	2.9	1.4	.021

4 | DISCUSSION

4.1 | Consequences of COVID-19 pandemic for patients needing elective invasive procedures

The Coronavirus Disease 2019 (COVID-19) pandemic has affected millions of people, and up to November 2020, more than 1.3 million

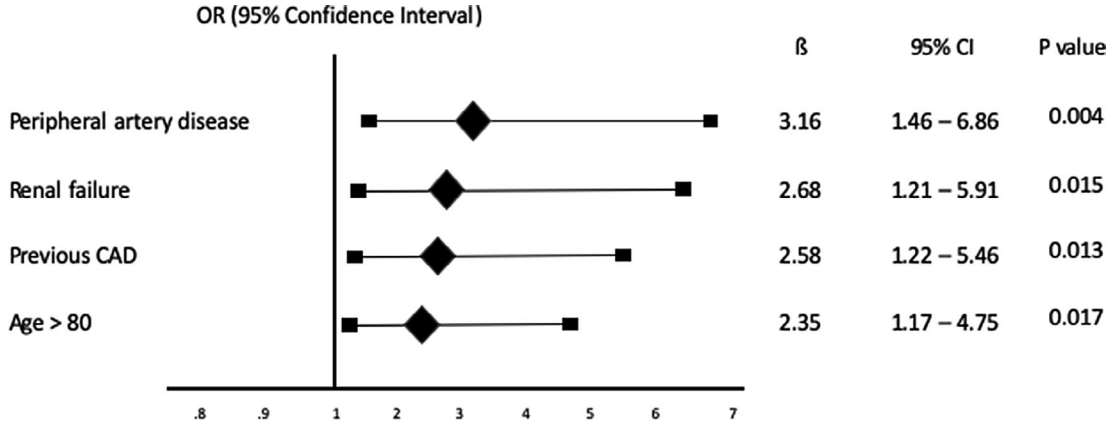

FIGURE 4 Independent predictors of COVID-19 disease

patients have died because of the infection.[2] Health care organizations have been overwhelmed worldwide, with exhaustion of all resources, hence hindering the correct management of patients with chronic diseases. Moreover, as the SARS-CoV-2 is easily spread, the risk of contamination in patients coming to health care centers is real. Because of all that, thousands of scheduled surgeries, and invasive procedures had to be canceled or postponed. As a result, a waiting list of thousands of patients was formed (Figure 5).

There are some diseases in which delaying life-saving procedures may cause fatal consequences. This may be the case of oncologic or cardiovascular procedures, for which the possibility of mortality during prolonged wait times is a matter of concern.[7] In particular, the activity of interventional cardiology includes a number of procedures that effectively treat some potentially lethal cardiac diseases, such as CAD[8] and valvular heart diseases.[9]

In Spain, the first case of COVID-19 was confirmed on the 31th of January, and the first death on the 13th of February, with an increasing number of cases reaching >1.3 millions of cases, and > 50,000 deaths related to the disease or its complications by November 2020. In the vast majority of hospitals, invasive procedures were canceled of postponed for patients with chronic cardiac diseases, although STEMI networks were maintained.[4,10]

In our study, 2,158 patients were pending on elective invasive procedures in the catheterization laboratories in 37 hospitals in Spain when the state of alarm was declared.[6] Coronary angiography and/or PCI comprised 53.2% of the population, but there was also a high proportion of patients (around 1/4) pending on structural interventions, including TAVI, LAAC, percutaneous closure of ASD, percutaneous mitral valve repair and others.

Out of these patients, 36 (1.7%) had died by the 31th of April, that is, mortality rate was 1.1%/month. There were 8.3% of patients in whom the procedure was performed urgently due to clinical unstabilization, and mortality during waiting list could have been higher in case these procedures would not have been performed.

The mortality rate was significantly higher in patients pending on structural procedures, mainly in those pending on percutaneous mitral valve repair, TAVI or LAAC. Patients that are deemed candidates for TAVI or percutaneous mitral valve repair have usually very advanced valve disease, and frequently need prompt intervention. In one study, the probability of wait-list mortality in patients scheduled for TAVI was ≈ 2% at 80 days.[11] In the PARTNER 1-B study, all-cause mortality at 1 and 3 months was 2.8% and ≈20%, respectively, in patients left on medical treatment.[12] In our study, mortality at 1.5 months of patients pending on TAVI was 4.9%, that is consistent with those data from the PARTNER trial. In patients with severe mitral regurgitation, mortality rate at 6 months was ≈ 10% in some studies.[13,14] In our study, mortality at 1.5 months of patients pending on percutaneous mitral valve repair was 8%, that is higher than expected, although all of them died from noncardiovascular causes.

The clinical outcome of patients with stable CAD is more benign. Some studies have exhibited a very good clinical outcome of patients on a wait list both for surgical or percutaneous myocardial revascularization.[15,16] In the ISCHEMIA trial, mortality rate at 6 months in patients allocated to conservative treatment was 0.4%, reflecting the favorable clinical outcome of stable CAD on optimal medical treatment.[17] The mortality rate in patients pending on diagnostic coronary angiography and/or PCI in our study was 1%. In the ISCHEMIA, some high risk subgroups, such as patients with severe renal failure, recent acute coronary syndrome, unprotected left main stenosis of at least 50%, NYHA class III or IV, and unacceptable angina despite the use of medical therapy at maximum acceptable doses, were excluded,[17] but these patients were included in our series.

The type of pending procedure (e.g., structural procedure or TAVI) was not an independent predictor of mortality and cardiovascular mortality. Patients pending on structural procedures are usually elderly, and have some co-morbidities, that may have a more clear impact on mortality. Diabetes, age and chronic renal failure, were independent predictors of global and cardiovascular mortality. These three characteristics are very well known factors associated with worse clinical outcome in different cardiovascular diseases.[18-21]

4.2 | COVID-19 disease in patients on waiting list

1.7% of patients included in the waiting list had a confirmed COVID-19 disease, and mortality in these patients was 29.8%. Both COVID-19 confirmed infection and mortality rates in patients with

FIGURE 5 Summary including the pending procedure, the proportion of patients suffering death, cardiovascular death and COVID-19 infection, and those needing an urgent procedure due to clinical unstabilization, as well as characteristics associated with these events in the univariable and multivariable analysis [Color figure can be viewed at wileyonlinelibrary.com]

COVID-19 in our study were higher than those occurring in the general population in Spain in April 2020 (≈0.5%, and ≈10%, respectively). Previous cardiovascular disease itself, advanced age, and comorbidities present in patients pending on invasive cardiac procedures constitute very well-known risk factors for COVID-19 disease.[22,23] In our study, advanced age, CAD, peripheral artery disease, and chronic renal failure were independently associated with the risk of infection.

4.3 | Clinical implications: Patient selection

During the acute phase of COVID-19 pandemic, elective invasive cardiac procedures were canceled or postponed.[4] To mitigate the impact of prolonged waits in interventional cardiovascular procedures, clear criteria for prioritizing patients may be crucial.[24,25] Among these patients there are very heterogeneous groups of patients, with very different risk during the waiting list. Accordingly to our results, there are some patients in whom it would have been more reasonable to perform the procedure, such as those >80, with diabetes or chronic renal failure. These patients had a relatively high mortality and cardiovascular mortality. In patients with more severe symptoms (NYHA > II and CCS > II), procedures were performed during the study period despite the COVID-19 pandemic. We can speculate that these patients could have also suffered a high mortality in case the procedure was not performed.

4.4 | Study limitations

This study has several limitations. First, the type of patients included is very heterogeneous, having made somewhat difficult to identify

concrete procedures as predictors of death in the multivariable analysis. However, some patients (e.g., those pending on TAVI) are easy to identify for patient selection during pandemic, because they had a significantly higher overall and cardiovascular mortality in the univariable analysis. Second, some patients underwent an urgent procedure due to clinical unstabilization. This may have underestimated a worse clinical outcome of some types of patients in case the procedure would not have been performed. Because of that, one of the secondary end-points was the combination of death or need for urgent procedure. Third, participating hospitals were heterogeneous, with different local protocols, and located in regions with different incidence of COVID-19. Four, this study did not have an independent clinical events committee, and hence events were adjudicated by local investigators. Finally, the diagnostic test of COVID-19 disease was not performed routinely in all patients included in the waiting list. Therefore, the incidence of COVID-19 infection has been probably underestimated.

5 | CONCLUSION

During COVID-19 pandemic, elective procedures were canceled or postponed in most units of interventional cardiology in Spain. This had important consequences in terms of short-term mortality. We found clear risk factors for mortality in this population, that can be of help for patient selection for second waves of this pandemic or future similar situations we may suffer in the future.

CONFLICT OF INTEREST

The authors declare no conflict of interest.

DATA AVAILABILITY STATEMENT

The data that support the findings of this study are available from the corresponding author upon reasonable request.

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REFERENCES

1. World Health Organization. Coronavirus disease 2019 (COVID-19) situation report - 78. Geneva: WHO; 2020.
2. Johns Hopkins Coronavirus Resource Center. Johns Hopkins Coronavirus Resource Center; 2020. https://coronavirus.jhu.edu/https://www.gouvernement.fr/info-coronavirus/carte-et-donnees.
3. Romaguera R, Cruz-González I, Jurado-Román A, et al. Considerations on the invasive management of ischemic and structural heart disease during the COVID-19 coronavirus outbreak. Consensus statement of the interventional cardiology association and the ischemic heart disease and acute cardiac Care Association of the Spanish Society of cardiology. REC Interv Cardiol. 2020;2:106-111.
4. Moreno R, Ojeda S, Romaguera R, Jimenez-Quevedo P, Cruz-González I. Transcatheter aortic valve replacement during COVID-19 pandemic. Recommendations from the Association of Interventional Cardiology of the Spanish Society of Cardiology (ACI-SEC). REC: Interv Cardiol. 2020;2:230-231.
5. Rodríguez-Leor O, Cid-Álvarez B, Ojeda S, et al. Impact of the COVID-19 pandemic on interventional cardiology activity in Spain. REC: Interv Cardiol. 2020;2:82-89.
6. Real Decreto 463/2020, de 14 de marzo, por el que se declara el estado de alarma para la gestión de la situación de crisis sanitaria ocasionada por el COVID-19. BOE núm. 67, de 14 de marzo de 2020, páginas 25390 a 25400. https://www.boe.es/eli/es/rd/2020/03/14/463.
7. Mourey L, Falandry C, de Decker L, Boulahssass R, Carola E, Bengrine Lefevre L. Taking care of older patients with cancer in the context of COVID-19 pandemic. Lancet Oncol. 2020;21(5):e236.
8. SEC Working Group for the 2019 ESC guidelines on chronic coronary syndromes, Expert Reviewers for the 2019 ESC guidelines on chronic coronary syndromes, SEC Guidelines Committe; SEC Working Group for the 2019 ESC guidelines on chronic coronary syndromes; SEC Guidelines Committee. Comments on the 2019 ESC guidelines on chronic coronary syndromes. Rev Esp Cardiol. 2020;73:439-444.
9. Otto CM. Informed shared decisions for patients with aortic stenosis. N Engl J Med. 2019;380:1769-1770.
10. Moreno R, Alonso JJ, Caballero R, et al. Influence of age and gender on arrival of patients with ST-segment elevation acute myocardial infarction to tertiary centers during COVID-19 pandemic. Experience of Madrid, Spain, STEMI network (Codigo Infarto Madrid). Am J Emerg Med. 2020. https://doi.org/10.1016/j.ajem.2020.06.013. [Epub ahead of print].
11. Elbaz-Greener G, Mashi S, Fnag J, et al. Temporal trends and clinical consequences of wait times for transcatheter aortic valve replacement. A population-based study. Circulation. 2018;138:483-493.
12. Leon MB, Smith CR, Mack M, et al. Transcatheter aortic-valve implantation for aortic stenosis in patients who cannot undergo surgery. N Engl J Med. 2010;363:1597-1607.
13. Obadia JF, Messika-Zeitoun D, Leurent G, et al. Percutaneous repair or medical treatment for secondary mitral regurgitation. N Engl J Med. 2018;379:2297-2306.
14. Stone GW, Lindenfeld J, Abraham WT, et al. Transcatheter mitral-valve repair in patients with heart failure. N Engl J Med. 2018;379:2307-2231.
15. Talwar S, Karpha M, Thomas R, et al. Disease progression and adverse events in patients listed for elective percutaneous coronary intervention. Postgrad Med J. 2005;81:459-462.
16. Head SJ, da Costa BR, Beumer B, et al. Adverse events while awaiting myocardial revascularization: a systematic review and meta-analysis. Eur J Cardiothorac Surg. 2017;52:206-217.
17. Maron DJ, Hochman JS, Reynolds HR, et al. Initial invasive or conservative strategy for stable coronary disease. N Engl J Med. 2020;382:1395-1407.
18. Norhammar A, Malmberg K, Diderholm E, et al. Diabetes mellitus: the major risk factor in unstable CAD even after consideration of the extent of CAD and benefits of revascularization. J Am Coll Cardiol. 2004;43:585-591.
19. Moreno R, Lopez de Sa E, Lopez-Sendon JL, et al. Prognosis of medically stabilized unstable angina pectoris with a negative exercise test. Am J Cardiol. 1998;82:662-665.

20. Go AS, Chertow GM, Fan D, McCulloch CE, Hsu C-Y. Chronic kidney disease and the risks of death, cardiovascular events, and hospitalization. N Engl J Med. 2004;351:1296-1305.
21. Pellikka PA, Sarano ME, Nishimura RA, et al. Outcome of 622 adults with asymptomatic, hemodynamically significant aortic stenosis during prolonged follow-up. Circulation. 2005;111:3290-3295.
22. Gao Q, Hu Y, Dai Z, Xiao F, Wang J, Wu J. The epidemiological characteristics of 2019 novel coronavirus diseases (**COVID**-19) in Jingmen, Hubei, China. Medicine (Baltimore). 2020;99(23):e20605.
23. Suleyman G, Fadel RA, Malette KM, et al. Clinical characteristics and morbidity associated with coronavirus disease 2019 in a series of patients in metropolitan Detroit. JAMA Netw Open. 2020;3(6):e2012270.
24. Chung CJ, Nazif TM, Wolbinski M, et al. The restructuring of structural heart disease practice during the Covid-19 pandemic. J Am Coll Cardiol. 2020;75:2974-2983.
25. Shah PB, Welt FGP, Mahmud E, et al. Triage considerations for patients referred for structural heart disease intervention during the coronavirus disease 2019 (COVID-19) pandemic: an ACC/SCAI consensus statement. JACC Cardiovasc Interv. 2020;13:1484-1488.

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