



Cardiac surgery during the COVID-19 pandemic

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Abstract

The COVID-19 pandemic had several specific as well as general implications on cardiac surgery. Acute respiratory distress made extracorporeal oxygenation necessary in a significant number of patients and accordingly many patients were treated in anesthesiological and even more in cardiac surgical intensive care units, which left only a limited number of beds in the intensive care units available for elective surgery cases. Moreover, the necessary availability of intensive care beds for severely diseased COVID-19 patients in general posed a further limit, as did the relevant number of diseased personnel. Specific emergency plans were developed for many heart surgery units, limiting the number of elective cases. Increasing waiting lists were of course stressful for numerous elective-surgery patients and the decreased number of heart operations also meant a financial burden for many units.

Keywords

SARS-CoV-2 · Extracorporeal membrane oxygenation · Heart surgery · Critical care · Surgical intensive care

During the initial phase of the COVID-19 pandemic, the core pathology presented as severe pneumonia and rapidly developing lung failure. It became clear very soon that noninvasive measures of respiratory support would not be sufficient for many severely diseased patients and that even invasive ventilation would not suffice in a relevant number of cases [1]. We all remember the first pictures from Wuhan and not much later from northern Italy, where intensive care units were overwhelmed by a wave of respirator-dependent patients, and very quickly the majority of critical care resources were allocated to COVID patients [2].

Early in the pandemic it also became clear that existing resources could not meet the needs of these numerous severely diseased and at the same time highly infectious patients. Personal protective equipment (PPE) such as face masks or shields, goggles, and protective gowns or gloves, which had hardly ever been scarce in recent decades, were suddenly not suffi-

ciently available, posing a significant risk for hospital staff. Furthermore, the need for mechanical ventilation in so many patients at the same time led to a shortage of ventilators and respective intensive care spaces [2].

First consequences for surgical specialties

Initially, major surgeries with a possible need for postoperative surveillance in an intensive care or even intermediate care unit were immediately cancelled or postponed, except for emergencies. The operating room staff was reduced to a minimum to save PPE for the personnel in other areas who had direct contact with COVID patients. Operating rooms were recruited as additional intensive care spaces, as they offered the necessary connections for oxygen and compressed air, which were needed for the operation of additional ventilators [1]. Furthermore, the risks of a perioperative COVID infection had to be

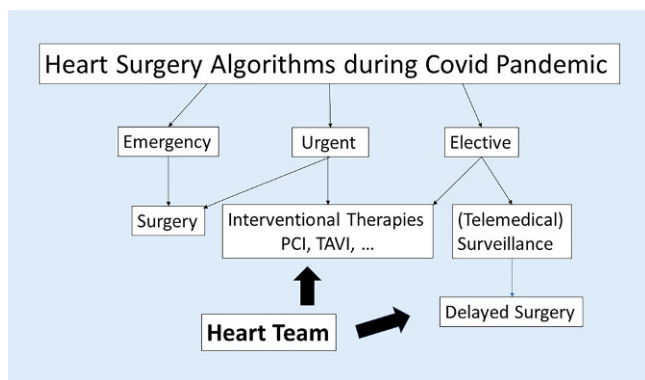


Fig. 1 ◀ Treatment algorithm of patients scheduled for cardiac operations during the pandemic. *PCI* percutaneous coronary intervention, *TAVI* transcatheter aortic valve implantation

weighed against the risks of postponing a non-emergent intervention [3]. Last but not least, an increasing number of hospital staff members acquired a COVID infection and were no longer freely available, which further aggravated the preexisting shortage of doctors and especially of nurses.

What about cardiac surgery during the pandemic?

Among the surgical disciplines, cardiac surgery is known to have the highest rate of patients who need postoperative surveillance in an intensive care unit. Accordingly, this specialty was immediately affected by the wave of COVID patients overwhelming the intensive care units, and many cardiac surgery units had to reduce their programs immediately at the beginning of the pandemic. But this was not the only challenge during the pandemic.

The heart and COVID

What was initially considered a very severe viral pulmonary infection, soon turned out to be a multiorgan disease affecting, for example, the vascular, the nervous, and the coagulation system as well as the heart. Although not generally seen in all patients, viral myocarditis and pericarditis further complicated many cases. Also, the number of arrhythmias increased among COVID patients, especially atrial fibrillation and, together with the coagulopathy, the risk of thromboembolisms increased as well. However, this coagulopathy not only complicated cardiac pathologies such as arrhythmia but it induced additional pathologies as well. One of them was pulmonary embolism, caused by peripheral macrothrombi. We soon

learned that an underlying central pathological entity during a COVID infection was endotheliitis, which was typically associated with permeability disturbances but, together with or even causative for the coagulopathies, caused disseminated microthrombi, also in the peripheral small pulmonary vessels and in the intramyocardial coronary bed [4]. As a consequence, alveolar gas exchange was additionally restricted and, concerning the heart, we saw more disseminated myocardial ischemias, other than the typical myocardial infarctions following stenoses of the epicardial coronary vessels. Indeed, valvular involvement was very rarely seen.

Most of these cardiac conditions or complications did not necessitate cardiac surgical interventions, except perhaps for a few large and critical pulmonary embolisms. However, they still influenced the daily routine insofar as a severely impaired gas exchange, induced or co-induced by the peripheral vascular thrombi, indicated extracorporeal gas exchange and some severe cases of myocarditis also needed extracorporeal support via arteriovenous extracorporeal membrane oxygenation (ECMO).

Moreover, it already became obvious in the very early phase of the pandemic that preexisting cardiac pathologies significantly increased the risk of severe courses and of mortality [5].

Critical care and ECMO

Although they represent the core business of cardiovascular surgery, the number of typical heart operations decreased acutely and significantly, while by contrast the need for two other competencies increased significantly: critical care

and extracorporeal lung and—in a few cases—also cardiac support. As already described, most intensive care units were very soon occupied by COVID patients. This was especially true for most heart surgical intensive care units with relevant experience in and wide-ranging equipment for cardiopulmonary critical care, such as oxygenators and ventilators, both scarce items during the initial waves of the pandemic [5, 6].

Additionally, ECMO techniques were also established in most heart surgical intensive care units and, accordingly, a majority of patients requiring arteriovenous ECMOs in particular were referred to these units where pump technicians were of course involved in the surveillance of these systems. Accordingly, the majority of the personnel were tied to the intensive care units and no longer available for routine work [1].

Risk of COVID vs. cardiac risk

As already outlined, patients with cardiac pathologies were especially susceptible to a severe course of COVID infection. This was a further reason to delay elective operations, especially during the first high wave of the pandemic and before vaccines were available. Perioperative infections, albeit not very frequent, were associated with a significantly increased mortality. The dilemma remained, however, that persistent heart disease per se also increased the individual risk for hospitalization or for a severe course of disease.

A large study by the universities of Charlottesville in Virginia and Ann Arbor in Michigan showed that, independent of socioeconomic status, heart surgical interventions during the pandemic were associated with a significantly increased risk-adjusted mortality and substantially higher hospital costs [7].

Management consequences

Out of the given reasons, most heart centers around the world reduced their elective operations significantly, by between 40% and 80% of the usual case load, depending on the respective procedures. Interventional procedures such as percutaneous transluminal coronary angioplasty

or transcatheter aortic valve implantation were recommended if possible to avoid major open-heart surgery and accordingly the decrease in their number was less pronounced [5]. Only emergency cases such as aortic dissections, acute coronary pathologies not amenable to interventional measures or associated with ventricular septal defect or papillary muscle rupture, acute valvular pathologies with shock symptoms, or transplantations were still performed in the usual manner. Even in these cases, interventional techniques such as transcatheter aortic valve implantation were always considered an alternative. In some instances, even transplantations had to be delayed [8]. Most centers defined their own criteria for emergent, urgent, and elective cases with respect to the given local limitations and risks [6]. Telemedical surveillance was implemented for patients on the waiting list, and patients were referred to other hospitals across borders. With the availability of vaccines and decreasing numbers of hospitalizations related to COVID infections, heart surgery programs were slowly rebooted; however, most of them are not back to normal to date [6, 9]. Whereas the numbers of infected patients in intensive care units have indeed decreased substantially and are no longer a limiting problem in most hospitals, doctors and even more so nurses have left their jobs after the pandemic. The new variants of the virus no longer cause severe courses among a mostly vaccinated population but they have a higher transmission rate and accordingly lead to increased employee illness among hospital staff members. Finally, the lower numbers of operations have also led to a limited training of surgical residents, which also contributes to the bottleneck in surgical care (■ Fig. 1).

Financial consequences

The significant decrease in the number of patients in most heart surgery programs has also had financial consequences. Reimbursement for heart operations went down and reimbursement for the critical care treatment of COVID patients did not cover the true costs for personnel, technical equipment, and medication. Even with financial aid from the state, many car-

Herzchirurgie während der COVID-19-Pandemie

Die COVID-19-Pandemie hatte eine Reihe spezifischer wie auch genereller Einflüsse auf die Herzchirurgie. Akute Atemnot erforderte bei einer erheblichen Anzahl von Patienten eine extrakorporale Oxygenierung, und so wurden eine Reihe dieser Patienten auf anästhesiologischen und v. a. herzchirurgischen Intensivstationen behandelt, was zu einer nur noch begrenzten Anzahl von Betten auf den Intensivstationen für elektive herzchirurgische Operationen führte. Zudem führte der generelle Bedarf von Intensivbetten für schwer kranke COVID-19-Patienten zu weiteren Begrenzungen, ebenso wie die erhebliche Anzahl erkrankter Mitarbeiter. Viele herzchirurgische Kliniken entwickelten spezielle Notfallpläne und begrenzten die Anzahl elektiver Eingriffe. Die wachsende Warteliste bedeutete natürlich für viele Patienten eine erhebliche psychische Belastung, und ebenso bedeutete die geringere Anzahl von Herzoperationen auch eine teils erhebliche finanzielle Belastung für viele Kliniken.

Schlüsselwörter

SARS-CoV-2 · Extrakorporale Membranoxygenierung · Herzchirurgie · Intensivmedizin · Chirurgische Intensivbehandlung

diovascular surgery units and accordingly many major hospitals have faced financial deficits during the past 2–3 years.

Consequences for the future

The COVID pandemic did not arrive totally unexpectedly and a similar situation may reoccur in the future. We must be better prepared. The availability of sufficient personal protective equipment must be guaranteed, including disinfection agents, as well as specific medications. Supply chains for medications must be secured and the dependence on producers outside Europe should be lessened. We must further foster research on antivirals, vaccines for different age groups, and provide sufficient anti-inflammatory drugs. We have to implement emergency plans, on the public level as well as on the individual hospital level. The recruitment of hospital staff and appropriate financing should be guaranteed. Physicians and nurses have to be reimbursed in a fair manner according to their increased risk and workload. We have managed this pandemic fairly well, but we must do better next time.

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Declarations

Conflict of interest. R. Moosdorf declares that he has no competing interests.

For this article no studies with human participants or animals were performed by any of the authors. All studies mentioned were in accordance with the ethical standards indicated in each case.

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