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REVIEW ARTICLE

Impact on the Solid Organ Transplant Waiting List During the Covid-19 Pandemic: An Integrative Review

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ABSTRACT

Introduction: With the Covid-19 pandemic, many medical procedures underwent significant changes due to the reallocation of resources to patients infected with Sars-Cov-2. The logistics of transplants were directly affected, with important repercussions for the patient on the waiting list for a new organ. **Objective:** This review seeks to analyze the impact of the Covid-19 pandemic on the logistics of solid organ availability and volume of transplants. **Methods:** An integrative search of articles with the descriptors "Covid OR Sars-Cov-2", "COVID-19", "Transplant", "Donor", "Waiting list", and "Organ donation" in PubMed and Web of Science was performed. Only articles on pancreas, heart, liver, kidney and intestine transplantation that addressed one of the following topics were considered: availability of donors, volume and time on the waiting list, mortality of patients on the waiting list, and volume of transplants performed. **Results:** Of the 68 articles found, 49 of them were multicentric. Among all 68, 29 made a statement concerning donor volume, 42 concerning transplant volume, 18 about mortality on the transplant waiting list, 15 concerning the volume on the waiting list, and 4 regarding time on the waiting list. Thus, with such data, in general, it was possible to observe a decrease in the volume of donors and the volume of transplants, besides a reduction in addition to the waiting list and an increase both in the waiting time for transplantation and in the mortality of the patients waiting for the transplant. **Conclusion:** The SARS-CoV-2 pandemic has directly influenced the logistics of solid organ transplants globally. The reasons that led to this fact are related to the decrease in the availability of ICU beds, contamination of the donor by the virus, and strict protocols to prevent the transmission of the virus.

Descriptors: Covid; Organ Transplantation; Pandemic; Organ Donation.

Impacto na Fila de Espera dos Transplantes de Órgãos Sólidos Durante a Pandemia de Covid-19: Uma Revisão Integrativa

RESUMO

Introdução: Com a pandemia da Covid-19, muitos procedimentos médicos sofreram alterações significativas devido à realocação de recursos para os pacientes contaminados pelo Sars-Cov-2. A logística de transplantes foi diretamente afetada, com repercussões importantes para o paciente na fila de espera para um novo órgão. **Objetivo:** Esta revisão busca analisar o impacto da pandemia da Covid-19 na logística de disponibilidade de órgãos sólidos e volume de transplantes. **Métodos:** Foi realizada uma busca integrativa de artigos com os descritores "Covid OR Sars-Cov-2", "COVID-19", "Transplant", "Donor", "Waiting list", "Organ donation" no PubMed e Web of Science. Só foram considerados artigos sobre transplante de pâncreas, coração, fígado, rim e intestino, e que abordassem um dos seguintes tópicos: disponibilidade de doadores, volume e tempo na lista de espera, mortalidade dos pacientes em espera, volume de transplantes realizados. **Resultados:** Dos 68 artigos encontrados, 49 deles eram multicêntricos. Dentre todos os 68, 29 fizeram alguma colocação em relação ao volume de doador, 42 em relação ao volume de transplante, 18 em relação à mortalidade na fila de transplante, 15 em relação ao volume da lista de espera e quatro

em relação ao tempo na lista de espera. Com tais dados, de forma geral, foi possível observar diminuição do volume de doadores e do volume de transplantes, redução de adições à lista de espera, e aumento tanto no tempo de espera para transplantes, quanto na mortalidade do paciente que aguardava pelo transplante. **Conclusão:** A pandemia da SARS-CoV-2 prejudicou diretamente a logística dos transplantes de órgãos sólidos de forma global. Os motivos que levaram a tal fato estão relacionados à diminuição dos leitos de UTI, contaminação do doador pelo vírus, e protocolos rigorosos para prevenção de transmissibilidade do vírus.

Descritores: Covid; Transplante de Órgãos; Pandemia; Doação de Órgãos.

INTRODUCTION

The pandemic resulting from the SARS-CoV-2 virus, which emerged in 2019, brought profound changes to medical practices worldwide. Due to the clinical repercussions, which affected ICU vacancies,[1]many of the hospital resources have been shifted toward the care of patients with Covid-19, mainly in public hospitals.[2] This change in dynamics led to the reduction or cancellation of surgical procedures, mainly of an elective nature.[3]

Initially, there was no suspension of solid organ transplants due to the emergency nature of the procedure. However, due to intra and postoperative complications,[4] putting patient safety at risk, several centers have restricted the volume of transplants or even suspended them.[2] In a statement by the World Health Organization (WHO), it was highlighted that ten of the 17 transplantation centers analyzed limited their activities during the pandemic period.[5] As a result, there was a reduction in the availability of donors,[6] reductions in waiting list additions[7] and recipient mortality.[8] Concerning patients with chronic kidney disease, in particular, there was an overload of dialysis centers.[9]

Thus, this article seeks to carry out an integrative review of studies that address the logistics of solid organ donation and transplantation during the Covid-19 pandemic to measure the impacts generated by the disease on patients on the waiting list.

METHODOLOGY

The present is a qualitative study in an integrative review format, intending to analyze possible changes in the logistics of solid organ transplants worldwide due to the Covid-19 pandemic. A bibliographic search was carried out in the following DATABASES - PUBMED and Web of Science -selecting scientific articles with original cases published from the beginning of the pandemic until the moment of selection of articles (September 2021).

The following search strategies were performed:

- Web of Science DATABASE:

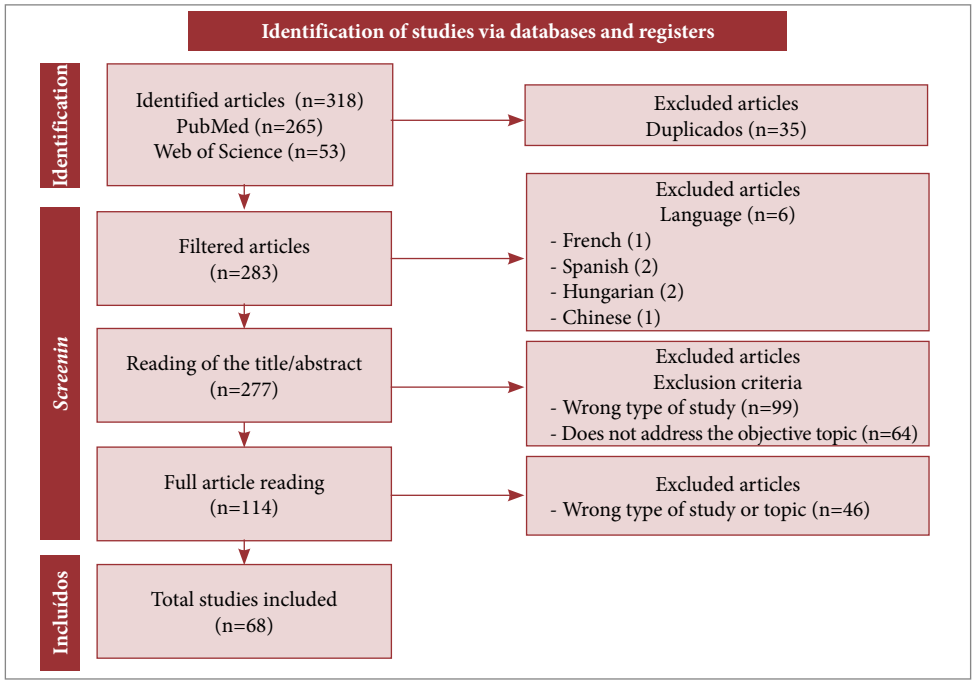
(Covid OR Sars-Cov-2 OR COVID-19) AND (Transplant*) AND (Donor OR Waiting list OR Organ donation).

- PUBMED DATABASE:

((Covid[Title/Abstract] OR Sars-Cov-2[Title/Abstract] OR COVID-19[Title/Abstract]) AND (Transplant*[Title/Abstract]) AND (Donor[Title/Abstract] OR Waiting list[Title/Abstract] OR Organ donation[Title/Abstract])) NOT ((Covid[Title/Abstract] OR Sars-Cov-2[Title/Abstract] OR COVID-19[Title/Abstract]) AND (Transplant*[Title/Abstract]) AND (Donor[Title/Abstract] OR Waiting list[Title/Abstract] OR Organ donation[Title/Abstract]) AND (case reports[Filter] OR review[Filter] OR systematic review[Filter])).

The difference in search between DATABASEs is due to the peculiarities of the functioning of this software. In PUBMED, the following descriptors were restricted: "Covid", "Sars-Cov-2", "COVID-19", "Transplant", "Donor", "Waiting list", "Organ donation" to the title/abstract; in the Web of Science, the same descriptions were used, restricting the search to the titles of the articles. The online tool RAYYAN - Intelligent Systematic Review was used for article selection, considering the PRISMA Statement 2020 search strategy. The tool has a duplicate article filter. Three reviewers initially selected the articles by reading the title and abstract. This selection was made individually, using the "blind mode" function, in which a reviewer does not have access to the inclusion or exclusion decisions of others, seeking to reduce the occurrence of biases. If there were disagreements between the reviewers, a fourth would make an evaluation and tiebreaker. After the complete reading, 68 articles were selected, divided among the reviewers and analyzed independently. The review has not been registered.

The following criteria were used for screening articles: articles in English or Portuguese; observational, retrospective or prospective articles; and clinical trials. Only the following organs were considered: pancreas, intestine, heart, lung, liver and kidney. Case reports, literature reviews, and letters to the reader were excluded, in addition to articles that do not fit the focus of research on solid organ transplantation logistics, such as clinical repercussions (Fig. 1). The search priority was based on the following logistical changes: availability of donors, volume and time on the waiting list, mortality of patients on waiting, and the volume of transplants performed. Such results are described in Table 1. The CAT (Critically Appraised Topic) Manager App was used to assess the risks of study bias. The following limitations were identified: the presence of a non-randomized study. A methodological analysis of each article was not performed.



Source: Elaborated by the authors.

Figure 1. Preferred reporting items for the integrative review flowchart (PRISMA).

RESULTS

General data

In analyzing the 68 selected articles, approximately 49 were carried out in multicenter studies (Table 1). Quantitatively, studies in the United States (29 articles) stood out. The most cited solid organ was the kidney in about 27 articles, followed by the liver in 25 articles (Fig. 2, Table 1). The main objective of the studies was to quantify the impacts on the transplantation system during the pandemic in relation to previous years and to suggest new strategies for performing transplants.

Table 1. List of articles referring to the mentioned variables.

Monocentric	Georgiades *et al.* (2021)[13]	Saracco *et al.* (2021)[30]	Balsara *et al.* (2021)[24]
	Karolak *et al.* (2021)[15]	Boedecker *et al.* (2021)[31]	Soin *et al.* (2021)[48]
	Halpern *et al.* (2020)[23]	Sahin *et al.* (2022)[33]	Bhatti *et al.* (2021)[54]
	Dogar *et al.* (2021)[26]	Araújo *et al.* (2020)[35]	Cristelli *et al.* (2021)[55]
	Varma *et al.* (2021)[27]	Muller *et al.* (2020)[37]	Caliskan *et al.* (2021)[56]
	Simone *et al.* (2020)[28]	Xu *et al.* (2021)[38]	Cheung *et al.* (2021)[61]
	Pestana et al. (2021)[29]	Hudgins et al. (2021)[45]	Manzia *et al.* (2021)[62]
Multicentric	Maggi *et al.* (2020)[1]	Ribeiro Junior *et al.* (2021)[18]	Ito *et al.* (2022)[47]
	Servin-Rojas *et al.* (2021)[2]	Filippis *et al.* (2020)[19]	González-Vílchez *et al.* (2021)[49]
	Boyarsky *et al.* (2020)[3]	Strauss *et al.* (2021)[20]	Mamode *et al.* (2021)[51]
	Charnaya *et al.* (2021)[4]	Watschinger *et al.* (2020)[22]	Bordes *et al.* (2020)[52]
	Chew et al. (2020)[5]	Ashfaq *et al.* (2021)[25]	Hardman *et al.* (2021)[53]
	Boyarsky *et al.* (2020)[6]	Anderson *et al.* (2021)[32]	Thind *et al.* (2021)[57]
	Chan *et al.* (2021)[7]	Caliskan *et al.* (2022)[34]	Arias-Murillo *et al.* (2021)[58]
	Russo *et al.* (2022)[8]	Ahmed *et al.* (2020)[36]	Turco *et al.* (2021)[59]
	Miller *et al.* (2021)[9]	Couzi *et al.* (2021)[39]	Ravanan *et al.* (2020)[60]
	Reddy *et al.* (2020)[10]	Peters *et al.* (2021)[40]	Varghese *et al.* (2021)[63]
	Benvenuto *et al.* (2021)[11]	Vries *et al.* (2020)[41]	Cristelli *et al.* (2022)[64]
	Kemme *et al.* (2021)[12]	Goff *et al.* (2021)[42]	Doshi *et al.* (2021)[65]
	Belli *et al.* (2021)[14]	Immer *et al.* (2020)[43]	Strauss *et al.* (2020)[66]
	Sharma *et al.* (2020)[16]	Cannavò *et al.* (2020)[44]	Meshram *et al.* (2022)[67]
	Bittermann *et al.* (2021)[17]	Angelico *et al.* (2020)[46]	Tan *et al.* (2021)[68]

Source: Elaborated by the authors.

Donor availability

Of the 68 articles selected, 29 mentioned the availability of donors – three reported an increase in this volume, four demonstrated that there was no change, and 22 demonstrated a reduction (Table 2).

Studies in Italy and UK[10] scored an important reduction of 95%[1] and 80%, respectively. In the United States (USA), there was a lower donation rate, mainly in services located in high-incidence areas, while low-exposure regions were not affected.[11]

Among the studies with an increase in solid organ donation, one article points out a change in the configuration of the donation profile, with an increase in donors in the age group between ten and eighteen years old, due to the reconfiguration of family dynamics with social isolation.[12] Another study points to a significant increase of 54.8% of donors due to brain death, however, without specifying the causal factor.[13]

Mortality on the transplant waiting list

Of the 68 articles selected, one showed a reduction, four showed no change, and 13 reported an increase in this volume (Table 2).

As a general trend, there was an increase in mortality in transplant waiting lists. In a multicenter study evaluating the global impact of the pandemic, patient mortality on the liver transplant waiting list was 52.3% higher when compared to 2019, with the highest value in European centers, followed by the Americas.[8] In the United States, it was reported that, during the first months of the onset of the pandemic, there was an increase of 189% in pediatric patients removed from the transplant list due to death or worsening of the condition.[4] Regarding adult patients, there was an increase of 49.2% in those with decompensated cirrhosis.[14]

Regarding the type of solid organ, there is a higher mortality on the kidney transplant waiting list compared to the lists of other organs.[9]

Waiting list

Of the selected articles, one showed no change in the number of people on the transplant list, another showed a divergence between studied groups, four reported an increase, and nine showed a reduction (Table 2).

In a global study with 470 centers, it was observed that 60.7% of the centers had a higher number of patients listed in 2019; 32.5% had a higher number of patients listed in 2020 and 6.8% had the same number of patients listed.[8]

In Poland, the waiting list increased from 120 to 152 people between 2019 and 2020.[15] In the United Kingdom, kidney transplants increased by 283 patients per month on the waiting list between March and September 2020.[16] In a study analyzing liver transplants in the US, there was a 106% increase in candidates on the waiting list.[17] According to the Brazilian Transplantation Registry (Registro Brasileiro de Transplantes-RBT), active patients were added to the waiting list for heart and kidney transplants in 2020; however, there were generally no significant changes.[18]

On the other hand, other works demonstrate a reduction in the total number of individuals on the transplant waiting list, as in the United States, where a decrease of 38% was observed.[19] Also in the United States, but considering more centers, there was an 11% drop in additions to waiting lists.[20] As for lung transplants in the same country, there was a decrease of 40%.[21] Looking again at lung transplants, however, in UK centers, new registrations dropped by 68%.[21] In another study in Austria, there were no considerable changes.[22]

Considering the waiting list time, two showed an increase, and two showed a divergence between different groups analyzed in the same research. Among the two that increased, one scored the increase from 11 to 13 days in the average waiting time in the transplant waiting list23, while the other pointed to an increase of 44 days compared to the pre-covid period.[12]

Regarding the two diverged studies, one pointed out that the minimum waiting time increased from 112.94 days to 147.44, and the maximum time decreased from 260.11 to 195.85 days.[24] Regarding the second study, the waiting time decreased by 28 days for pediatric patients, but it increased by forty days for adults.[25]

Transplant volume

Of the 68 articles selected for the review, two reported divergences between the studied groups, one reported no change, six reported an increase, and 33 reported a reduction in the volume of transplants (Table 2).

A study carried out in six centers in three countries showed a variation in the reduction according to the country, with a decrease of 25% in the USA and more than 80% in India and the United Kingdom.[9]

A few studies describe an increase in the performance of transplants.[14,17,23–26,55] In a multicenter survey carried out in Pakistan, there was no impairment in the volume of transplants, including an increase in the monthly average from 10.1 to 14.0.[26] It is pertinent to highlight the specific methods adopted in the hospital environment to control contamination, such as routine Covid-19 tests among patients and the professional team.

Table 2. List of articles referring to the mentioned variables.

Variable	Waiting list mortality		
Increase	Charnaya *et al.* (2021)[4]	Belli *et al.* (2021)[14]	Hudgins *et al.* (2021)[45]
	Chew *et al.* (2020)[5]	Strauss *et al.* (2021)[20]	Ito *et al.* (2022)[47]
	Boyarsky *et al.* (2020)[6]	Hardman *et al.* (2021)[21]	Mamode *et al.* (2021)[51]
	Russo *et al.* (2022)[8]	Peters *et al.* (2021)[40]	
	Miller *et al.* (2021)[9]	Goff *et al.* (2021)[42]	
Decrease	-	-	-
Unchanged	Benvenuto *et al.* (2021)[11]	Saracco *et al.* (2021)[30]	Boedecker *et al.* (2021)[31]
	Karolak *et al.* (2021)[15]		
Not specified	Maggi *et al.* (2020)[1]	Simone *et al.* (2020)[28]	Bordes *et al.* (2020)[52]
	Servin-Rojas *et al.* (2021)[2]	Pestana *et al.* (2021)[29]	Hardman *et al.* (2021)[53]
	Boyarsky *et al.* (2020)[3]	Anderson *et al.* (2021)[32]	Bhatti *et al.* (2021)[54]
	Chan *et al.* (2021)[7]	Sahin *et al.* (2022)[33]	Cristelli *et al.* (2021)[55]
	Reddy *et al.* (2020)[10]	Caliskan *et al.* (2022)[34]	Caliskan *et al.* (2021)[56]
	Kemme *et al.* (2021)[12]	Araújo *et al.* (2020)[35]	Thind *et al.* (2021)[57]
	Georgiades *et al.* (2021)[13]	Ahmed *et al.* (2020)[36]	Arias-Murillo *et al.* (2021)[58]
	Sharma *et al.* (2020)[16]	Muller *et al.* (2020)[37]	Turco *et al.* (2021)[59]
	Bittermann *et al.* (2021)[17]	Xu *et al.* (2021)[38]	Ravanan *et al.* (2020)[60]
	Ribeiro Junior *et al.* (2021)[18]	Couzi *et al.* (2021)[39]	Cheung *et al.* (2021)[61]
	Filippis *et al.* (2020)[19]	Vries *et al.* (2020)[41]	Manzia *et al.* (2021)[62]
	Watschinger *et al.* (2020)[22]	Immer *et al.* (2020)[43]	Varghese *et al.* (2021)[63]
	Halpern *et al.* (2020)[23]	Cannavò *et al.* (2020)[44]	Cristelli *et al.* (2022)[64]
	Balsara *et al.* (2021)[24]	Angelico *et al.* (2020)[46]	Doshi *et al.* (2021)[65]
	Ashfaq *et al.* (2021)[25]	Soin *et al.* (2021)[48]	Strauss *et al.* (2020)[66]
	Dogar *et al.* (2021)[26]	González-Vílchez *et al.* (2021)[49]	Meshram *et al.* (2022)[67]
	Varma *et al.* (2021)[27]	Benden *et al.* (2020)[50]	Tan *et al.* (2021)[68]
Variable	Donor availability		
Increase	Russo *et al.* (2022)[8]	Georgiades *et al.* (2021)[13]	Ashfaq *et al.* (2021)[25]**
Decrease	Maggi *et al.* (2020)[1]	Strauss *et al.* (2021)[20]	Hudgins *et al.* (2021)[45]
	Boyarsky *et al.* (2020)[6]	Hardman *et al.* (2021)[21]	Ito *et al.* (2022)[47]
	Chan *et al.* (2021)[7]	Saracco *et al.* (2021)[30]	Bordes *et al.* (2020)[52]
	Reddy *et al.* (2020)[10]	Sahin *et al.* (2022)[33]	Hardman *et al.* (2021)[53]
	Benvenuto *et al.* (2021)[11]	Araújo *et al.* (2020)[35]	Caliskan *et al.* (2021)[56]
	Sharma *et al.* (2020)[16]	Xu *et al.* (2021)[38]	Turco *et al.* (2021)[59]
	Ribeiro Junior *et al.* (2021)[18]	Goff *et al.* (2021)[42]	Cheung *et al.* (2021)[61]
Unchanged	Kemme *et al.* (2021)[12]	Dogar *et al.* (2021)[26]	
	Karolak *et al.* (2021)[15]	Varma *et al.* (2021)[27]	
Not specified	Servin-Rojas *et al.* (2021)[2]	Anderson *et al.* (2021)[32]	Bhatti *et al.* (2021)[54]
	Boyarsky *et al.* (2020)[3]	Caliskan *et al.* (2022)[34]	Cristelli *et al.* (2021)[55]
	Charnaya *et al.* (2021)[4]	Ahmed *et al.* (2020)[36]	Thind *et al.* (2021)[57]
	Chew *et al.* (2020)[5]	Muller *et al.* (2020)[37]	Arias-Murillo *et al.* (2021)[58]
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	Belli *et al.* (2021)[14]	Peters *et al.* (2021)[40]	Manzia *et al.* (2021)[62]
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	Watschinger *et al.* (2020)[22]	Cannavò *et al.* (2020)[44]	Doshi *et al.* (2021)[65]
	Halpern *et al.* (2020)[23]	Angelico *et al.* (2020)[46]	Strauss *et al.* (2020)[66]
	Balsara *et al.* (2021)[24]	Soin *et al.* (2021)[48]	Meshram *et al.* (2022)[67]
	Simone *et al.* (2020)[28]	González-Vílchez *et al.* (2021)[49]	Tan *et al.* (2021)[68]
	Pestana *et al.* (2021)[29]	Benden *et al.* (2020)[50]	
	Boedecker *et al.* (2021)[31]	Mamode *et al.* (2021)[51]	
Variable	Waiting list time		
Increase	Kemme *et al.* (2021)[12]	Ashfaq *et al.* (2021)[25]**	Strauss *et al.* (2020)[66]
Decrease	Ashfaq *et al.* (2021)[25]**		
Unchanged	Ribeiro Junior *et al.* (2021)[18]		
Not specified	Maggi *et al.* (2020)[1]	Dogar *et al.* (2021)[26]	Ito *et al.* (2022)[47]
	Servin-Rojas *et al.* (2021)[2]	Varma *et al.* (2021)[27]	Soin *et al.* (2021)[48]
	Boyarsky *et al.* (2020)[3]	Simone *et al.* (2020)[28]	González-Vílchez *et al.* (2021)[49]
	Charnaya *et al.* (2021)[4]	Pestana *et al.* (2021)[29]	Benden *et al.* (2020)[50]
	Chew *et al.* (2020)[5]	Saracco *et al.* (2021)[30]	Mamode *et al.* (2021)[51]
	Boyarsky *et al.* (2020)[6]	Boedecker *et al.* (2021)[31]	Bordes et al. (2020)[52]
	Chan *et al.* (2021)[7]	Anderson *et al.* (2021)[32]	Hardman et al. (2021)[53]
	Russo *et al.* (2022)[8]	Sahin *et al.* (2022)[33]	Bhatti et al. (2021)[54]
	Miller *et al.* (2021)[9]	Caliskan *et al.* (2022)[34]	Cristelli *et al.* (2021)[55]

Continue...

Table 2. Continuation.

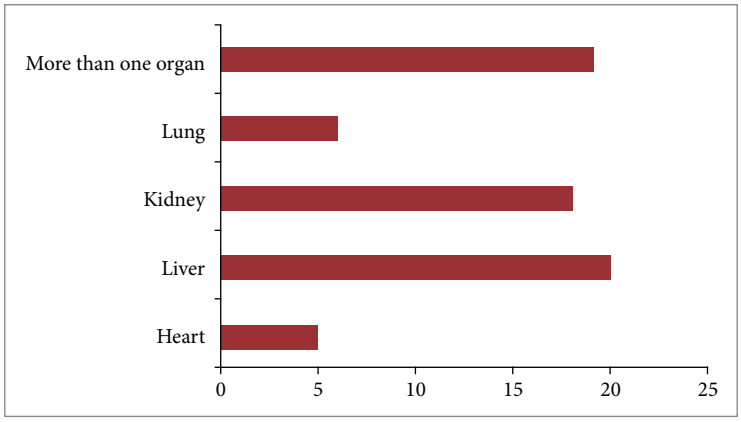
Not specified	Reddy *et al.* (2020)[10]	Araújo *et al.* (2020)[35]	Caliskan *et al.* (2021)[56]
	Benvenuto *et al.* (2021)[11]	Ahmed *et al.* (2020)[36]	Thind *et al.* (2021)[57]
	Georgiades *et al.* (2021)[13]	Muller *et al.* (2020)[37]	Arias-Murillo *et al.* (2021)[58]
	Belli *et al.* (2021)[14]	Xu *et al.* (2021)[38]	Turco *et al.* (2021)[59]
	Karolak *et al.* (2021)[15]	Couzi *et al.* (2021)[39]	Ravanan *et al.* (2020)[60]
	Sharma *et al.* (2020)[16]	Peters *et al.* (2021)[40]	Cheung *et al.* (2021)[61]
	Bittermann *et al.* (2021)[17]	Vries *et al.* (2020)[41]	Manzia *et al.* (2021)[62]
	Filippis *et al.* (2020)[19]	Goff *et al.* (2021)[42]	Varghese *et al.* (2021)[63]
	Strauss *et al.* (2021)[20]	Immer *et al.* (2020)[43]	Cristelli *et al.* (2022)[64]
	Hardman *et al.* (2021)[21]	Cannavò *et al.* (2020)[44]	Doshi *et al.* (2021)[65]
	Watschinger *et al.* (2020)[22]	Hudgins *et al.* (2021)[45]	Meshram *et al.* (2022)[67]
	Halpern *et al.* (2020)[23]	Angelico *et al.* (2020)[46]	Tan *et al.* (2021)[68]
Variable	Number of candidates on the transplant waiting list		
Increase	Russo *et al.* (2022)[8]**	Sharma *et al.* (2020)[16]	Anderson *et al.* (2021)[32]
	Karolak *et al.* (2021)[15]	Bittermann *et al.* (2021)[17]	Muller *et al.* (2020)[37]
Decrease	Chan *et al.* (2021)[7]	Hardman *et al.* (2021)[21]	Meshram et al. (2022)[67]
	Russo *et al.* (2022)[8]**	Goff *et al.* (2021)[42]	Tan et al. (2021)[68]
	Filippis *et al.* (2020)[19]	Hardman et al. (2021)[53]	
	Strauss *et al.* (2021)[20]	Manzia et al. (2021)[62]	
Unchanged	Watschinger *et al.* (2020)[22]		
Not specified	Maggi *et al.* (2020)[1]	Simone *et al.* (2020)[28]	González-Vílchez *et al.* (2021)[49]
	Servin-Rojas *et al.* (2021)[2]	Pestana *et al.* (2021)[29]	Benden *et al.* (2020)[50]
	Boyarsky *et al.* (2020)[3]	Saracco *et al.* (2021)[30]	Mamode *et al.* (2021)[51]
	Charnaya *et al.* (2021)[4]	Boedecker *et al.* (2021)[31]	Bordes *et al.* (2020)[52]
	Chew *et al.* (2020)[5]	Sahin *et al.* (2022)[33]	Bhatti *et al.* (2021)[54]
	Boyarsky *et al.* (2020)[6]	Caliskan *et al.* (2022)[34]	Cristelli *et al.* (2021)[55]
	Miller *et al.* (2021)[9]	Araújo *et al.* (2020)[35]	Caliskan *et al.* (2021)[56]
	Reddy *et al.* (2020)[10]	Ahmed *et al.* (2020)[36]	Thind *et al.* (2021)[57]
	Benvenuto *et al.* (2021)[11]	Xu *et al.* (2021)[38]	Arias-Murillo *et al.* (2021)[58]
	Kemme *et al.* (2021)[12]	Couzi *et al.* (2021)[39]	Turco *et al.* (2021)[59]
	Georgiades *et al.* (2021)[13]	Peters *et al.* (2021)[40]	Ravanan *et al.* (2020)[60]
	Belli *et al.* (2021)[14]	Vries *et al.* (2020)[41]	Cheung *et al.* (2021)[61]
	Ribeiro Junior *et al.* (2021)[18]	Immer *et al.* (2020)[43]	Varghese *et al.* (2021)[63]
	Halpern *et al.* (2020)[23]	Cannavò *et al.* (2020)[44]	Cristelli *et al.* (2022)[64]
	Balsara *et al.* (2021)[24]	Hudgins *et al.* (2021)[45]	Doshi *et al.* (2021)[65]
	Ashfaq *et al.* (2021)[25]	Angelico *et al.* (2020)[46]	Strauss *et al.* (2020)[66]
	Dogar *et al.* (2021)[26]	Ito *et al.* (2022)[47]	
	Varma *et al.* (2021)[27]	Soin *et al.* (2021)[48]	
Variable	Transplant volume		
Increase	Russo *et al.* (2022)[8]**	Balsara *et al.* (2021)[24]	Pestana *et al.* (2021)[29]**
	Bittermann *et al.* (2021)[17]	Ashfaq *et al.* (2021)[25]	Cristelli *et al.* (2021)[55]
	Halpern *et al.* (2020)[23]	Dogar *et al.* (2021)[26]	
Decrease	Servin-Rojas *et al.* (2021)[2]	Filippis *et al.* (2020)[19]	Hudgins *et al.* (2021)[45]
	Boyarsky *et al.* (2020)[3]	Strauss *et al.* (2021)[20]	Angelico *et al.* (2020)[46]
	Charnaya *et al.* (2021)[4]	Hardman *et al.* (2021)[21]	Ito *et al.* (2022)[47]
	Boyarsky *et al.* (2020)[6]	Simone *et al.* (2020)[28]	González-Vílchez *et al.* (2021)[49]
	Chan *et al.* (2021)[7]	Pestana *et al.* (2021)[29]**	Hardman *et al.* (2021)[53]
	Russo *et al.* (2022)[8]	Caliskan *et al.* (2022)[34]	Bhatti *et al.* (2021)[54]
	Reddy *et al.* (2020)[10]	Ahmed *et al.* (2020)[36]	Thind *et al.* (2021)[57]
	Benvenuto *et al.* (2021)[11]	Muller *et al.* (2020)[37]	Turco *et al.* (2021)[59]
	Kemme *et al.* (2021)[12]	Vries *et al.* (2020)[41]	Varghese *et al.* (2021)[63]
	Georgiades *et al.* (2021)[13]	Immer *et al.* (2020)[43]	Meshram *et al.* (2022)[67]
	Ribeiro Junior *et al.* (2021)[18]	Cannavò *et al.* (2020)[44]	Tan *et al.* (2021)[68]
Unchanged	Varma *et al.* (2021)[27]		
Not specified	Maggi *et al.* (2020)[1]	Sahin *et al.* (2022)[34]	Caliskan *et al.* (2021)[56]
	Chew *et al.* (2020)[5]	Araújo *et al.* (2020)[35]	Arias-Murillo *et al.* (2021)[58]
	Belli *et al.* (2021)[14]	Xu *et al.* (2021)[38]	Ravanan *et al.* (2020)[60]
	Karolak *et al.* (2021)[15]	Couzi *et al.* (2021)[39]	Cheung *et al.* (2021)[61]
	Sharma *et al.* (2020)[16]	Peters *et al.* (2021)[40]	Manzia *et al.* (2021)[62]
	Watschinger *et al.* (2020)[22]	Goff *et al.* (2021)[42]	Doshi *et al.* (2021)[65]
	Saracco *et al.* (2021)[30]	Benden *et al.* (2020)[50]	Strauss *et al.* (2020)[66]
	Boedecker *et al.* (2021)[31]	Mamode *et al.* (2021)[51]	
	Anderson *et al.* (2021)[32]	Bordes *et al.* (2020)[52]	

*Study did not specify the type of organ; **Results differ between different groups
Source: Elaborated by the authors.

Table 3. List of articles referring to the type of solid organ addressed.

	Studies		
Heart	Filippis *et al.* (2020)[19]	Ashfaq *et al.* (2021)[25]	Hardman *et al.* (2021)[53]
	Balsara *et al.* (2021)[24]	González-Vílchez *et al.* (2021)[49]	
Lung	Chan *et al.* (2021)[7]	Karolak *et al.* (2021)[15]	Halpern *et al.* (2020)[23]
	Benvenuto *et al.* (2021)[11]	Hardman *et al.* (2021)[21]	Sahin *et al.* (2022)[33]
Kidney	Charnaya *et al.* (2021)[4]	Boedecker *et al.* (2021)[31]	Thind *et al.* (2021)[57]
	Boyarsky *et al.* (2020)[6]	Caliskan *et al.* (2022)[34]	Manzia *et al.* (2021)[62]
	Georgiades *et al.* (2021)[13]	Couzi *et al.* (2021)[39]	Cristelli *et al.* (2022)[66]
	Sharma *et al.* (2020)[16]	Peters *et al.* (2021)[40]	Doshi *et al.* (2021)[65]
	Watschinger *et al.* (2020)[22]	Bordes et al. (2020)[52]	Strauss *et al.* (2020)[66]
	Pestana *et al.* (2021)[29]	Cristelli et al. (2021)[55]	Meshram *et al.* (2022)[67]
Liver	Maggi *et al.* (2020)[1]	Strauss *et al.* (2021)[20]	Muller *et al.* (2020)[37]
	Chew *et al.* (2020)[5]	Dogar *et al.* (2021)[26]	Soin *et al.* (2021)[48]
	Russo *et al.* (2022)[8]	Varma *et al.* (2021)[27]	Bhatti *et al.* (2021)[54]
	Reddy *et al.* (2020)[10]	Simone *et al.* (2020)[28]	Turco *et al.* (2021)[59]
	Kemme *et al.* (2021)[12]	Saracco *et al.* (2021)[30]	Varghese *et al.* (2021)[63]
	Belli *et al.* (2021)[14]	Anderson *et al.* (2021)[32]	Tan *et al.* (2021)[68]
	Bittermann *et al.* (2021)[17]	Araújo *et al.* (2020)[35]	
More than one organ	Servin-Rojas *et al.* (2021)[2]	Goff *et al.* (2021)[42]	Mamode *et al.* (2021)[51]
	Boyarsky *et al.* (2020)[3]	Immer *et al.* (2020)[43]	Caliskan *et al.* (2021)[56*]
	Miller *et al.* (2021)[9]	Cannavò *et al.* (2020)[44]	Arias-Murillo *et al.* (2021)[58]
	Ribeiro Junior *et al.* (2021)[18]	Hudgins *et al.* (2021)[45*]	Ravanan *et al.* (2020)[60]
	Ahmed *et al.* (2020)[35]	Angelico *et al.* (2020)[46]	Cheung *et al.* (2021)[61]
	Xu *et al.* (2021)[38]	Ito *et al.* (2022)[47]	
	Vries *et al.* (2020)[41]	Benden *et al.* (2020)[50]	

*Study did not specify the type of organ; **Results differ between different groups
Source: Elaborated by the authors.



Source: Elaborated by the authors.
Figure 2. Organs transplanted in the referred studies.

DISCUSSION

The Covid-19 pandemic brought new challenges and perspectives for performing solid organ transplantation. The expressive number of multicenter studies shows the international collaboration for the development of solutions, with a survey with the participation of 470 transplant centers distributed in 21 countries.[8] It was necessary to develop strict protocols to attest to the safety of the patient and the health team, even with the emergency nature of the procedure.[19,27] Remote monitoring of patients was one of the alternatives implemented by some countries, such as Italy, to provide medical assistance to users awaiting transplants and carry out laboratory tests more frequently to identify contamination early.[28]

The rigor of donor testing protocols to minimize the transmissibility of Covid-19 during surgery,[10,29] associated with the difficulty of organ procurement logistics due to the greater restriction of flights,[23] had important repercussions in the decrease in the availability of donations, with a reduction rate of over 80% being evidenced in some centers.[10,11] Along with the reduction in

organ procurement, there was a reconfiguration of the donor profile, which was influenced by the change in interaction dynamics with social isolation. One study found an increase in the proportion of donors aged between 10 and 18 years,[12] being possibly justified by the rise in reports of family violence against the child due to the stressors of the restriction of coexistence.

Reducing the availability of organs directly impacts the increase in waiting time[24,25] and, finally, in increasing the patient's mortality. In the United States, 189% more pediatric patients than expected were removed from the kidney transplant waiting list due to death or worsening conditions due to failure to perform the procedure on time.[4] The most affected patients were on the kidney transplant list due to the greater demand for graft-patient compatibility compared to other solid organs. The unchanged mortality in some Centers[11,15,30,31] is due to the low prevalence of Covid-19 in the region and the service's resource for timely donor testing.[9]

Despite an expected increase in the number of patients in the transplant queue due to the unavailability of organs, some centers reported a reduction in the number of patients listed. There was a withdrawal from the procedure due to the fear of contracting Covid-19, even though the transplant was the only curative measure.[17] In addition, it was also observed that, with the measures of social isolation and less functioning of services specialized in terminal liver disease, fewer patients were identified and enrolled in the transplant waiting list.[7]

In general, most of the centers that served as the base for the research had their organ donation and transplant activities reduced or completely suspended. In the US, India and UK, there was a reduction of 25%, 80% and 80% respectively.[8] In addition to the factors mentioned above, the unavailability of ICU beds allocated to patients in serious conditions with Covid-19 made the logistics of the procedure challenging.[1] The King's College & Hospital in London scored an occupation of 90% of the beds by patients with Covid-19, with an important risk of transmission to the transplant patient, in serious condition, in the postoperative period.[10]

Despite the variability of results regarding the impact of the Covid-19 pandemic on solid organ donation and transplantation logistics, one must consider the heterogeneity of contamination in the affected regions and the infrastructure and resources of services to deal with the new dynamic.[21]

CONCLUSION

In short, it can be said that the Covid-19 pandemic, especially in the initial period, hampered most of the logistical processes of transplantation in the world, having a considerable impact on the availability of organs and, consequently, on the entire chain of stages necessary for the procedure. However, it is worth mentioning that some studies observed an increase in the volume of transplants performed compared to the pre-pandemic period, demonstrating a certain adaptability of these health services during the conjuncture of the SARS-CoV-2 virus.

CONFLICT OF INTEREST

Nothing to declare.

AUTHOR'S CONTRIBUTION

Substantive scientific and intellectual contributions to the study: Costa LRO, Furtado LCC, Braga RC, Brito BDB, Sales TJB, Motta DL, Nunes FHS, Schmidt YF, Silva HRS, Fonseca Neto OCL; **Conception and design:** Costa LRO, Furtado LCC, Braga RC, Brito BDB, Sales TJB, Motta DL, Nunes FHS, Schmidt YF; **Data analysis and interpretation:** Costa LRO, Furtado LCC, Braga RC, Brito BDB, Sales TJB, Motta DL, Nunes FHS, Schmidt YF; **Article writing:** Costa LRO, Furtado LCC, Braga RC, Brito BDB, Sales TJB, Motta DL, Nunes FHS, Schmidt YF; **Critical revision:** Costa LRO, Silva HRS, Fonseca Neto OCL. **Final approval:** Costa LRO, Silva HRS, Fonseca Neto OCL.

DATA AVAILABILITY STATEMENT

All datasets were generated or analyzed in the current study.

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