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Restarting LDLT During COVID-19: Early Results After Restructuring

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ABSTRACT

Introduction. Living-donor liver transplantation (LDLT) has been mostly suspended and deceased-donor living transplantation activity has been considerably reduced because of coronavirus disease 2019 (COVID-19). We modified our protocols and procedures in line with COVID-19 guidelines. Since the restructuring, we have performed 20 LDLTs. Our study reports the outcomes of these cases and demonstrates the feasibility of LDLT during this pandemic.

Materials and Methods. The changes were influenced by experiences and communications from across the globe. A month-long self-imposed moratorium was spent in restructuring the program and implementing new protocols. Twenty LDLTs were performed between April 18 and September 15 using the new protocols. Our experience includes 2 simultaneous liver-kidney transplants, 1 ABO-incompatible LDLT, and 1 pediatric case (age 11 months).

Results. Nineteen patients recovered and 1 patient died. We maintained our postoperative immunosuppression protocol without many changes. Major complications were observed in 30% of recipients but none of the donors. One recipient was infected with COVID-19 during the postoperative period. A donor-recipient couple contracted COVID-19 after discharge from the hospital. All patients recovered from COVID-19 and liver enzymes were unaffected.

Conclusion. This study represents a microcosm of experience in LDLT during the COVID-19 era. Outcomes of LDLT are not affected by COVID-19 per se, provided that we make necessary changes.

CORONAVIRUS DISEASE 2019 IN INDIA

CORONAVIRUS disease 2019 (COVID-19) struck India on January 30, with the first reported case in an Indian student in Wuhan. Lockdown was imposed across India on March 25, with relaxations starting in June. COVID-19 has slowly spread throughout the entire country, although the rate of increase has been slow. The daily number of cases and mortality quickly escalated once the lockdown was lifted (Fig 1).

COVID-19 AND IMPLICATIONS FOR LIVING DONOR LIVER TRANSPLANT

Living-donor liver transplantation (LDLT) requires intense resource utilization, close patient-to-personnel contact, and efficiently running ancillary services. An overwhelmed system is not an ideal situation for LDLT and, understandable,

LDLTs were suspended across the globe [1–6]. Patients with advanced or decompensated cirrhosis and hepatocellular carcinoma (HCC) are at high risk and can become unsalvageable if deferred too long. Deceased-donor liver transplantation has always been minimal in India even before the pandemic, because of unavailability of donors. LDLTs cannot be deferred for too long given the high short-term mortality. At what point does a recipient's mortality risk weighing the risk to the donor (double equipoise). South Korea reported a case of a living donor testing positive after

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COVID-19 in India

Parameter- Global Position(COVID-19 cases)*

Total Cases-2nd (7,233,670)

New Cases-1st(60,105)

Total deaths-3rd(110,588)

New deaths-1st(694)

Critical Cases-2nd(8,944)

Total cases per 1 million-80th(5227)

Total deaths per 1 million-81th(80)

** Numbers as reported on October 13, 2020*



Fig 1. Current coronavirus disease 2019 situation in India [20,21].

a liver donation [3]. There is no published series reporting on outcomes of LDLT during the COVID-19 crisis. During the severe acute respiratory syndrome (2003) and Middle East respiratory syndrome (2015) episodes, immunosuppression in the posttransplant period was not associated with mortality [7,8]. However, it would be prudent to consider immunosuppressed patients at high risk from COVID-19 [9]. Posttransplant patients with COVID-19 on immunosuppression may harbour the virus and transmit to others for a longer period.

COVID-19 GUIDELINES FOR LIVER TRANSPLANT

The Centers for Medicare & Medicaid Services [10] recommend that liver transplant, as a high-acuity surgery (tier 3b), need not be postponed. The American Association for the Study of Liver Diseases [11] recommends that transplant programs continuously assess their local situation and its impact on patients awaiting transplantation and hence a single overarching protocol is not recommended. The American Association for the Study of Liver Diseases [11] recommends suspending LDLT during the pandemic, except for pediatric patients with acute liver failure. They have provided recommendations on various aspects of liver transplantation such as immunosuppression, intensive care unit (ICU) protocols, transplant rounds, referrals among others. The Liver Transplant Society of India [12] called for a moratorium on nonurgent transplants but did not elaborate on what constitutes an urgent case other than acute liver failure and acute-on-chronic liver failure (ACLF). The National Organ and Tissue Transplant Organization [13,14], the apex organization for organ transplant in India, issued specific guidelines for nationwide transplant activity.

A model called “quadripartite equipoise” [15] has been developed from a multi-institutional study to address the ethical issues in transplantation during the COVID-19 crisis. There is published literature pertaining to restarting surgical services [10,13,14,16]; however, we found no guidelines or published series with regard to how to restructure LDLT programs during the COVID-19 pandemic.

MATERIALS AND METHODS

Adapting and Restructuring

Liver transplants, in many cases, may not be urgent but cannot be deferred indefinitely. Clear strategies were required to navigate through the pandemic as well as postpandemic era. The list of limiting factors that were dealt with progressively includes the following:

- Sanitizers, N95 masks, gloves, personal protective equipment kits, visors, etc.

- Availability of ventilators and ICU capacity.

- Staffing problems at all levels; that is, doctors, nurses, technicians, etc.

- Protocols to prioritize or defer a particular patient.

- Clearly worded, easy-to-understand protocols for outpatient department (OPD) consultations; informed consent; operating theater (OT) movements; intubation; surgical procedures including instrumentation and OT staffing and movements; and postoperative and postdischarge protocols.

- Creation of an “invisible barrier” between critical, immunocompromised, and elderly patients from excess hospital foot traffic [16].

- Visitor restrictions, culminating in a no-visitor policy in the early period of the COVID-19 crisis.

- Daily rounds were scheduled on online meeting applications for midday where all departmental personnel were present. Notwithstanding the initial glitches, it led to participation from all members of the team and more constructive inputs. With more experience,

academic programs and multidisciplinary tumor and transplant board meetings were also shifted to virtual meeting platforms.

A complete lockdown across India was announced on March 25 and implementation was exemplary. The impact on departmental activity was almost immediate. The OPD consultations and OT list were almost negligible compared to the pre-pandemic era. Routine follow-up consultations were discouraged, including among post-transplant patients. Clinical staff on our team were divided into 2 groups. One group was active for 3 days at a stretch and was responsible for all operative, clinical, and nonclinical work. The second team took over for the second half of the week. Within the 2 groups, personnel for inpatient and outpatient services were not allowed to intermingle. Personal protective equipment donning and doffing protocols were also formalized at the institutional level. Movement of personnel, trolleys, handovers, and preoperative patients was streamlined. Operational directives published by Cocolini et al [16] provided the foundations for the development of our own protocols. Because patients with COVID-19 were expected to be admitted to our center later during the COVID-19 crisis, movement corridors were planned to avoid COVID areas and elevators.

Our LDLT program was started in 2012 and our institution is a quaternary care center in the national capital region of India. The center has experienced a steady increase in the number of referrals from northern regions of India and from other countries. Before the pandemic, we performed a mean of 8 LDLTs per month. Since the announcement of a lockdown from March 25 to April 18, no liver transplants have been performed. Our hospital is a private institution that operates on third-party payers such as government agencies and out-of-pocket expenditure. Insurance coverage is minimal across India and, even if available, covers only a fraction of the cost of LDLT. The bulk of COVID-19 cases in New Delhi were handled by large tertiary public hospitals and a few private institutions (our center was excluded) designated as COVID-19 centers. The remaining health care institutions were directed to carry on services per COVID-19 guidelines so that non-COVID-19 patients did not suffer for lack of services. As new cases of COVID-19 increased in Delhi, private institutions like ours were entrusted to make available up to 25% of bed capacity for the care of patients with COVID-19 beginning at the end of June (the area designated for patients with COVID-19 was strictly separated from areas for non-COVID patients, and there was no crossover of personnel in these areas). However, both the government organization (National Organ and Tissue Transplant Organization) and professional bodies (Liver Transplant Society of India) recommended proceeding with urgent transplantation after careful evaluation on a case-by-case basis.

Rebooting LDLTs

Once the protocols were established, we decided to resume the LDLT program. We decided to limit our LDLTs to cases of acute liver failure/ACLF; with a high Model for End-Stage Liver Disease score, Child C, HCC >2 cm; pediatric cases; and cases with recurrent, frequent decompensation with high expected mortality within next 3 months. The decision to proceed with transplant evaluation was taken after discussion among transplant hepatologist, transplant surgeons, and critical care teams on a case-by-case basis. A COVID-19 screening questionnaire similar to the one proposed by Kumar et al [17] concerning COVID-19 infection, exposure/travel history, and symptoms was administered. Any case suspected of COVID-19 was directed toward the “suspected COVID” pathway and transplant-related evaluation was deferred

until the patient recovered or COVID-19 was ruled out. Donor and recipient nasopharyngeal samples underwent nucleic acid amplification testing (NAT) twice before LDLT. Turnaround time for NAT tests is 6 to 12 hours depending on the daily case load at our institution. Nasopharyngeal swabs were collected first thing in the morning and reporting was expedited so that we had the report by evening. The first testing was done at the initial visit in the OPD and the second was done 24 hours prior to LDLT. If the initial test was found to be positive, the patient was directed toward the COVID-19 pathway and no further transplant-related evaluation was done. The second test was done 24 hours prior to the transplant as per institutional protocol. If a patient tested positive for COVID-19 at any time, the transplant was deferred because COVID-19 positivity has poor postoperative outcomes [18]. Between the 2 tests, the patients were kept in home isolation as much as possible. Upon admission for LDLT, they were kept in isolated rooms and moved to the ICU once their NAT test was negative. Computed tomography of the chest was included while imaging the abdomen to ensure a low sensitivity for pulmonary complications. Person-to-person interaction was minimized, as was the time spent inside the hospital premises. The rest of transplant evaluation protocol was similar to that pre-COVID, with added preventive measures applicable to the COVID-19 crisis [19]. The entire transplant team including surgeons, anesthetists, critical care personnel, nursing staff, and technicians underwent NAT testing once during the lockdown period. Subsequently, liver transplant personnel were isolated and tested with reverse transcription-polymerase chain reaction if they had symptoms of COVID-19 or had close contact with a COVID-19-positive patient. The experiences and communications from transplant centers across the globe helped us to formulate our own path and navigate this pandemic. In this study we chronicle the changes in our LDLT protocol and share our experience of 20 successful LDLTs under the new paradigm.

Study Details

This study was performed at the Department of Hepato-Pancreato Biliary Surgery and Liver Transplant at BL Kapur Superspecialty Hospital, New Delhi, India. Major changes in infrastructure and protocols were made to deal with the pandemic. The study reports changes made in LDLT protocols during this period. We present a retrospective analysis of 20 LDLTs performed between April 18 and September 15. All cases were candidates for liver transplant as per indications. The urgency of each case and high risk of short-term mortality were confirmed in multidisciplinary discussions.

RESULTS

Almost a month after the implementation of a lockdown, we performed our first LDLT on April 18. At the time of initiation of liver transplant, the institutional, departmental, and OT protocols were already partially in practice among nontransplant patients. At the time of writing of this article, we successfully performed 20 LDLTs (Table 1), including 1 pediatric, 1 ABO-incompatible, and 2 simultaneous liver-kidney transplants (SLKTs). These cases required efficiency and meticulousness of the highest standards and tested our preparedness. The lockdown measures were significantly eased during the first week of June and the number of daily new cases and deaths has significantly increased. The impact of easing of lockdown restrictions on our LDLT program remains to be seen.

Table 1. Demographic Characteristics and Clinical Profiles of Patients Undergoing Living-Donor Liver Transplants

	Date	Age/Sex	Donor	Etiology	Indication for Urgency	Operative Procedure	Graft Type	Child Status	MELD	HCC	Comorbidity
1	18/04/2020	47/M	Wife	HBV+HDV	HRS+SBP	LDLT	Right	B	23	N	None
2	20/04/2020	36/M	Brother	HBV+HDV+HCV	Recurrent HE	LDLT	Right	C	13	N	Smoker
3	22/04/2020	68/M	Son	NASH	HCC	LDLT	Right	B	24	Y	DM, h/o GTCS
4	30/04/2020	42/M	Wife	Alcohol	Refractory ascites +HRS	LDLT (ABOI)	Right	C	20	N	None
5	06/05/2020	45/M	Wife	Alcohol	ACLF	LDLT	Right+ MHV	C	33	N	Smoker, TB
6	18/05/2020	44/M	Brother	Alcohol+NASH	HCC	SLKT	Right with partial MHV	C	22	Y	HTN, DM, diabetic nephropathy, ex-smoker
7	01/06/2020	11 mo/M	Mother	Biliary atresia	Recurrent cholangitis	Pediatric LDLT	Left lateral segment (hyper-reduced)	C	17 (PELD)	N	None
8	05/06/2020	35/M	Uncle	Primary oxalosis with CKD	Loss of HD access	SLKT	Right	A	24	N	None
9	12/06/2020	60/M	Son	HBV	HCC(TACE+RFA)	LDLT	Right with partial MHV	C	16	Y	DM
10	24/06/2020	49/M	Wife	Alcohol	Recurrent UGIB	LDLT	Right with partial MHV	C	17	N	Tobacco
11	02/07/2020	54/M	Sister	HCV	Child C	LDLT	Right with partial MHV	C	30	N	None
12	10/07/2020	33/M	Sister	Alcohol	ACLF	LDLT	Right with partial MHV	C	32	N	Tobacco
13	16/07/2020	34/M	Brother-in-law	NASH	ACLF	LDLT	Right	C	30	N	DM
14	18/07/2020	25/M	Brother	HBV	ACLF	LDLT	Left lobe	C	30	N	None
15	24/07/2020	60/M	Son	SBC+NASH	Recurrent SBP and HE	LDLT	Left lobe	C	23	N	DM
16	06/08/2020	44/M	Wife	Alcohol	ACLF	LDLT	Right without MHV	C	31.5	N	RHD+MS status BMV with AF
17	10/08/2020	58/M	Sister	Alcohol	Child C	LDLT	Right with partial MHV	C	21	N	DM, HTN
18	14/08/2020	30/M	Sister	HBV	Recurrent HE/UGIB	LDLT	Left lobe	C	16	N	None
19	25/08/2020	55/F	Son-in-law	HCV	Recurrent HE/Ascites	LDLT	Right without MHV	B	22.3	N	None
20	15/09/2020	53/F	Son	AIH	ACLF	LDLT	Left Lobe	C	38	N	DM, HTN

Abbreviations: ABOI, ABO-incompatible; ACLF, acute-on-chronic liver failure; AF, atrial fibrillation; AIH, autoimmune hepatitis; BMV, balloon mitral valvotomy; CKD, chronic kidney disease; DM, diabetes mellitus; GTCS, generalized tonic-clonic seizures; HBV, hepatitis B virus; HCC, hepatocellular carcinoma; HCV, hepatitis C virus; HD, hemodialysis; HDV, hepatitis D virus; HE, hepatic encephalopathy; h/o, history of; HRS, hepatorenal syndrome; HTN, hypertension; MELD, Model for End-Stage Liver Disease; MHV, middle hepatic vein; MS, mitral stenosis LDLT, living-donor transplant; NASH, nonalcoholic steatohepatitis; PELD, pediatric end-stage liver disease; RFA, radiofrequency ablation; RHD, rheumatic heart disease; SBC, secondary biliary cirrhosis; SBP, spontaneous bacterial peritonitis; SLKT, simultaneous liver-kidney transplant; TACE, transarterial chemoembolization; TB, tuberculosis; UGIB, upper gastrointestinal bleed.

All cases had urgent or semi-urgent indications for transplantation. Out of 20 cases, 6 had ACLF, 3 had HCC, 10 had Child C cirrhosis, and the mean Model for End-Stage Liver Disease score was 24.4. Seven of the 20 patients had diabetes mellitus, of whom 3 patients were over 60 years of age, which poses a high risk for mortality among COVID-19-positive patients. For all patients there were multiple rounds of counseling and multidisciplinary consultation. We also performed a video counseling and consent session during which the standard risk for transplant and added risk of COVID-19 infection was explained.

Nineteen patients transplanted between April 18 and September 15 are doing well and 1 died. The single death in the series is discussed in the next section. All recipients and donors had been discharged at the time of writing of this article. The mean hospital stay was 19.7 days (range, 13-39) among patients who were discharged. Mean graft-recipient weight ratio was 1.08 (range, 0.63-3.16). We were able to start tacrolimus on day 1 in 6 patients, on day 2 in 8 patients, on day 3 in 3 patients, on day 4 in 2 patients, and on day 5 in the pediatric patient. Postoperative parameters of patients undergoing LDLT are shown in Table 2.

Hospital Course and Complications

Six patients developed 8 major complications defined as Clavien-Dindo grade \geq III. Patient 3 (ABO-incompatible LDLT) was recovering well but on postoperative day (POD) 4 developed sudden-onset unresponsiveness. Imaging revealed a massive intracranial bleed with features of mass effect and herniation. The patient died on POD 10 and was the only death in this series. Patient 6 underwent SLKT and on POD 2 he developed pleural effusion requiring

inter-costal drain drainage. On POD 11, he had altered sensorium and breathlessness, which was thoroughly evaluated. Brain magnetic resonance imaging revealed multiple bilobar brain infarcts. The patient was started on anti-coagulation therapy. He had complete neurologic recovery in 36 hours but 2 days later developed bleeding from the renal bed. The patient was reexplored for hemostasis. Patient 8 also underwent SLKT (for primary hyperoxaluria). Both SLKT patients were tested for severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) in the post-operative period because of fever but neither was positive. The patient with primary hyperoxaluria had a relatively smooth course, whereas the other patient had a stormy course, as detailed earlier. Both patients recovered completely and were discharged (on days 17 and 23, respectively).

Patient 7 was a pediatric transplant for biliary atresia who had to be taken up for reexploration on POD 1 because of hemorrhagic drain. Intraoperatively there was a large hematoma in the right hypochondrium but no signs of active bleed. Thereafter, he had good improvement in sensorium and other clinical conditions including laboratory parameters. The patient recovered gradually but uneventfully and was discharged on POD 26.

Patient 10 had an uneventful recovery and was ready for discharge on POD 20 when he developed fever. He tested positive for COVID-19 (both rapid antigen and polymerase chain reaction tests were positive). The patient was isolated in the COVID-19 ICU and standard protocols were followed. Chest radiograph showed opacities consistent with COVID-19. The patient required intermittent noninvasive ventilation to maintain saturation. Mycophenolate was

Table 2. Postoperative Parameters of Patients Undergoing Living-Donor Liver Transplants

Date	Operative Procedure	DOD	LOHS	GRWR	COVID-19 Test	Gr \geq III	TAC POD	TAC@D	Donor LOHS	Gr \geq III Donor	Re-Ex	M	
1	18/04	LDLT	07/05	19	1.1	No	No	2	6.5	7	No	No	N
2	20/04	LDLT	08/05	18	0.87	No	No	1	4.01	6	No	No	N
3	22/04	LDLT	09/05	17	1.01	No	No	2	3.4	7	No	No	N
4	30/04	ABOI	10/05	10	0.78	No	V	1	NA	7	No	No	Y
5	06/05	LDLT	25/05	19	0.82	No	No	2	7.7	8	No	No	N
6	18/05	SLKT	10/06	23	0.8	POD13	IIIa, IIIb, IVa	2	9.9	8	No	Yes	N
7	01/06	Pediatric	27/06	26	3.16	No	IIIb	5	8	9	No	Yes	N
8	05/06	SLKT	22/06	17	1.41	POD11	No	1	4.24	6	No	No	N
9	12/06	LDLT	30/06	18	0.69	No	No	1	5.6	6	No	No	N
10	24/06	LDLT	31/07	37	0.7	POD21	IV	1	3.6	6	No	No	N
11	02/07	LDLT	16/07	14	0.94	No	No	2	5.5	6	No	No	N
12	10/07	LDLT	28/07	18	0.82	No	No	4	3.6	8	No	No	N
13	16/07	LDLT	31/07	15	0.63	No	No	4	4.1	10	No	No	N
14	18/07	LDLT	01/08	16	0.78	No	No	2	9.5	7	No	No	N
15	24/07	LDLT	15/08	21	1.09	No	No	2	9.1	7	No	No	N
16	06/08	LDLT	15/09	39	1.1	No	Yes (IIIb)	3	NA	10	No	Yes	N
17	10/08	LDLT	24/08	13	0.8	No	No	1	8.1	7	No	No	N
18	14/08	LDLT	10/09	25	1.6	No	Yes (IIIb)	3	2.2	7	No	Yes	N
19	25/08	LDLT	13/09	17	1.7	No	No	3	4.3	7	No	No	N
20	15/09	LDLT	28/09	13	0.94	No	No	2	5.7	7	No	No	N

Abbreviations: COVID-19, coronavirus disease 2019; DOD, date of discharge; Gr \geq III, Clavien-Dindo complication grade \geq 3 (major); GRWR, graft-recipient weight ratio; LDLT, living-donor liver transplant; LOHS, length of hospital stay; M, mortality; Re-Ex, re-exploratory surgery; TAC POD, postoperative day of tacrolimus induction; TAC@D, trough levels of tacrolimus at discharge.

withheld, the tacrolimus dose was reduced to half, and the patient was switched to intravenous steroids. Inflammatory markers were monitored and interleukin-6 was found to be significantly elevated. Convalescent plasma was administered on days 4 and 5 of COVID-19 infection. COVID-19 IgG levels were evaluated on day 6 and another 200 mL of convalescent plasma was administered to build up plasma IgG levels. Gradually he improved and his oxygen requirement came down. Aspirin and enoxaparin were continued. The patient was discharged on POD 37 (day 17 of COVID-19 infection) with normal liver function tests.

Contact tracing was done for ICU nursing staff and doctors for the week preceding patient 10's COVID-19 diagnosis). All health care personnel were tested and quarantined for 1 week. One nurse was found to be COVID-19-positive but was asymptomatic. He was then advised to home quarantine.

Patients 11 to 15 had a smooth postoperative case and were discharged within the expected time with no major complications. In 2 of these cases, introduction of calcineurin inhibitor was delayed because of preexisting acute kidney injury. None of these patients had any COVID-19-related symptoms and were not tested. Patient 16 developed hepatic artery thrombosis for which thrombolysis was performed. Patient 18 developed abdominal pain and was reexplored for suspected bowel perforation. The bowel perforation was found to be due to mucormycosis and the patient was started on antifungals and eventually recovered. Both patients were discharged albeit with slightly prolonged hospital course.

Seven patients had diabetes, of whom 3 were over 60 years of age, which poses a high risk of COVID-19-related mortality. None of them were infected with COVID-19 and the 3 patients over 60 years of age had a completely uneventful recovery.

None of the donors developed any symptoms of COVID-19 and none were tested. All had an uneventful recovery and were discharged after a mean hospital stay of 7.3 days (range, 6-10).

Follow-up

Although the follow-up period (range, 0-146 days) is extremely short, we had 100% compliance with follow-up. Telephonic updates are sought on a daily basis and the families are encouraged to use online modes of communication liberally. Laboratory investigations are performed locally and communicated to us. Physical visits are limited to interventions, liver Doppler, or development of symptoms.

The donor of patient 5 developed symptoms of fever and diarrhea 20 days after discharge. The patient was subsequently tested and found to be COVID-19-positive. Her liver function tests were found to be normal. Because the symptoms were well outside the incubation period, it was considered that she acquired from sources outside the hospital. Appropriate municipal authorities were informed regarding contact tracing but we did not test any health care

personnel based on contact tracing. She was admitted to the COVID-19 care ward and her symptoms improved after 3 days. The donor recovered uneventfully and was discharged after 5 days to quarantine at home.

Patient 5 (recipient [husband] of the COVID-19-positive donor) also developed fever 1 day after the donor developed symptoms. He had been discharged from the hospital 10 days earlier. He was also found to be COVID-19-positive and hence was admitted. Contact tracing among health care personnel involved in his care in the preceding 2 weeks was done. None of the health care personnel had displayed any symptoms and hence were not tested. This recipient had significant changes on chest x-ray and required oxygen support to maintain saturation. Immunosuppression was withheld and hydrocortisone was substituted. Empirical antimicrobial coverage was given. After 3 days of febrile illness and oxygen requirement, the patient recovered. Immunosuppression was restarted on day 4 of admission. The patient recovered uneventfully and was discharged after 5 days to quarantine at home.

DISCUSSION

The COVID-19 crisis has pushed all of us to find new and innovative solutions to old problems. The pandemic may take time to abate and may become much worse before it shows any trend toward improvement. Our own approach to LDLT has been a culmination of small adjustments and changes made along the way to navigate the pandemic. For a few weeks, no work was possible because we gauged the enormity of the situation and prepared for the impact. Soon, however, it became clear that the pandemic was not going to be of short duration. Hence, we worked to find ways to continue our work during the pandemic and during the post-COVID era. We assimilated experiences and approaches from across the globe and resumed LDLT.

All patients have been discharged at the time of writing of this article. The 1 death was due to massive intracranial bleed. There was no impact on mean length of hospital stay or our ability to start immunosuppression. We disregarded length of ICU stay as a parameter because all of our patients (donors and recipients) were managed from admission to discharge in the ICU (because of the COVID-19 pandemic). We usually start tacrolimus toward the evening of first postoperative day, when a reasonable amount of stability is seen in the clinical condition. Nevertheless, we start with a low initial dose and a low threshold to withdraw the tacrolimus depending on the clinical condition. We were able to maintain our pre-COVID immunosuppression schedule of triple immunosuppression (calcineurin inhibitor + mycophenolate mofetil + steroids) in most of the patients. We did not modify our immunosuppression (including tacrolimus trough levels) or antibiotic policy from the pre-COVID-19 era. During the postoperative course, we did not perform universal COVID-19 testing but were

guided by patient symptoms. Even those at high risk of COVID-19-related mortality (older patients with diabetes) had an uneventful recovery.

We tested 3 of 20 patients for COVID-19 during their hospital stays and 2 were found to be negative. The 1 patient who was infected with COVID-19 during the posttransplant period recovered after a prolonged hospitalization. The asymptomatic health care personnel was the possible source of infection. Subsequently, all health care staff were instructed to submit a self-declaration form for any probable contact with suspected COVID-19-positive patient. A mobile-based contact tracing application promulgated by government of India was checked on a daily basis before resuming duties. If any contact history with a suspected COVID-19-positive patient was present, the individual was quarantined for 7 days.

Incidence of major complications is on the higher side (~30%) in this study probably because of the very small sample size and the diverse and difficult set of patients.

All of the living donors, who are the crucial pivot of this double equipoise, recovered well and without complications. The mean length of hospital stay was 7.3 days (range, 6-10). The kidney donors were also discharged without any complications.

One of the donors also became infected with SARS-CoV-2 infection about 20 days after discharge. The donor presented with unusual symptomatology of acute gastroenteritis but turned out to be positive for COVID-19. It was only detected due to our institutional protocol of testing all patients for COVID-19 prior to admission. The donor had an uneventful recovery. The transplant recipients who developed SARS-CoV-2 posttransplant were continued on tacrolimus and low-dose steroid. The patients recovered uneventfully and were discharged. In both the recipients and the donor, liver enzymes were unaffected by COVID-19.

Our intention is to bolster other transplant programs to restart or continue LDLT, and we believe that this article answers the necessary safety concerns involved in this decision. The future course of the pandemic is still unclear and the health care infrastructure may soon be overwhelmed. Until then, we believe that we have robust processes in place to safely continue LDLT.

CONCLUSION

Our LDLT setup and protocols were modified to meet the challenges of the pandemic. These changes were required to reboot the LDLT program and the article chronicles these changes. Restarting the program was necessary to mitigate short-term mortality among high-risk cirrhotic patients. LDLT was offered after careful consideration on a case-by-case basis. This article presents the outcomes of 20 transplants performed during this period. In our experience, the COVID-19 pandemic itself does not have a bearing on the outcome of an uninfected LDLT recipient or donor, provided that necessary procedural and protocol modifications

have been made. As the only reported series of LDLTs in COVID-19 across the globe, this study may bolster other programs to restart LDLTs. However, in regions where health care systems have been overwhelmed, it may be prudent to suspend LDLT activities.

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