

# Hypercoagulability on thromboelastography after living donor hepatectomy—The true side of the coin

## Address for correspondence:

Dr. Gaurav Sindwani,  
Department of Anaesthesia,  
Institute of Liver and Biliary  
Sciences, New Delhi, India.  
E-mail: drsindwani25@gmail.  
com

Submitted: 23-Oct-2020

Revised: 18-Nov-2020

Accepted: 09-Feb-2021

Published: 15-Apr-2021

**Shankey Garg, Gaurav Sindwani, Neha Garg, Mahesh K Arora,  
Viniyendra Pamecha<sup>1</sup>, Deepak Tempe**

Departments of Anaesthesia and Intensive Care and <sup>1</sup>Hepato-pancreato-biliary Surgery and Liver Transplantation, Institute of Liver and Biliary Sciences, New Delhi, India

## ABSTRACT

**Background and Aims:** Coagulation dynamics after donor hepatectomy are complex. Having complete knowledge of the actual changes in the coagulation status during donor hepatectomy is important to prevent complications such as pulmonary embolism, deep vein thrombosis, and bleeding. Hence, the present study aimed to study the coagulation dynamics following open donor hepatectomy both by thromboelastography (TEG) and conventional coagulation tests (CCT). **Methods:** A total of 50 prospective liver donors were included. TEG and CCT [activated partial thromboplastin time (aPTT), prothrombin time (PT), international normalised ratio (INR), fibrinogen, and platelet counts] were performed for each patient before surgery (baseline), on postoperative day (POD) 0, 1, 2, 3, 5, and 10. **Results:** TEG showed hypercoagulability in 28%, 38%, 30%, 46%, 42%, and 48% patients; in contrast INR showed hypocoagulability in 58%, 63%, 73%, 74%, 20%, and 0% patients on POD 0, 1, 2, 3, 5, and 10, respectively. Patients demonstrating hypercoagulability on TEG had significantly decreased reaction time ( $P = 0.004$ ), significantly increased maximum amplitude ( $P < 0.001$ ), and alpha angle value ( $P < 0.001$ ). Postoperatively, INR, PT, and aPTT values increased significantly, while platelets and fibrinogen levels decreased significantly when compared to their baseline values. There was no coagulation-related postoperative complication in any of the patients. **Conclusion:** Hypercoagulability after donor hepatectomy is common. TEG showed hypercoagulability and did not show any hypocoagulability as suggested by the CCT. In patients undergoing donor hepatectomy, CCT may not reflect the actual changes in coagulation status and tests such as TEG should be performed to know the correct nature of changes in coagulation following donor hepatectomy.

**Key words:** Blood coagulation, hepatectomy, partial thromboplastin time, platelet count, prothrombin time, thromboelastography

## Access this article online

Website: [www.ijaweb.org](http://www.ijaweb.org)

DOI: 10.4103/ija.IJA\_1338\_20

Quick response code



## INTRODUCTION

Liver transplant is the only definitive curative option for patients with end-stage liver disease. Shortage of cadaveric liver organs<sup>[1]</sup> and a growing list of patients waiting for liver transplant has led to an increased interest in living donor liver transplantation.<sup>[2]</sup> Donor safety is of utmost importance in the living donor liver transplant program. Coagulation changes after hepatectomy are known to be complex and both hypo- and hypercoagulable states have been reported.<sup>[3,4]</sup> Hypocoagulable state can be a result of reduced synthesis of coagulation factors. In contrast, hypercoagulable state can result from

reduced levels of anticoagulation factors and increased level of factor VIII and von Willebrand factor.<sup>[5]</sup> These haemostatic abnormalities can be diagnosed either by conventional coagulation tests (CCTs) or

This is an open access journal, and articles are distributed under the terms of the Creative Commons Attribution-NonCommercial-ShareAlike 4.0 License, which allows others to remix, tweak, and build upon the work non-commercially, as long as appropriate credit is given and the new creations are licensed under the identical terms.

**For reprints contact:** [WKHLRPMedknow\\_reprints@wolterskluwer.com](mailto:WKHLRPMedknow_reprints@wolterskluwer.com)

**How to cite this article:** Garg S, Sindwani G, Garg N, Arora MK, Pamecha V, Tempe D. Hypercoagulability on thromboelastography after living donor hepatectomy—The true side of the coin. *Indian J Anaesth* 2021;65:295-301.

viscoelastic tests such as thromboelastography (TEG). CCT such as prothrombin time (PT), activated partial thromboplastin time (aPTT), and international normalised ratio (INR) detect abnormalities only in the procoagulant pathway and are used commonly to know the coagulation status of these patients. Interpretation of CCT in such patients may lead to inappropriate therapy by way of transfusion of various blood products and the associated complications such as deep vein thrombosis (DVT), bleeding, transfusion-related acute lung injury, and delayed removal of epidural catheter. Therefore, understanding the changes in the coagulation status accurately following donor hepatectomy is essential for appropriate treatment that will prevent such complications. In this respect, viscoelastic tests such as TEG that reflect the activity of both pro and anticoagulant status of the patient may be beneficial. Postoperative hypercoagulability is now a well-established feature in patients with hepatocellular carcinoma undergoing hepatectomy.<sup>[6]</sup> However, the results of these studies may not be applicable to the donor hepatectomy patients as they are otherwise healthy patients. Hence, the aim of the present study was to evaluate the changes in coagulation dynamics after donor hepatectomy by both TEG and CCT.

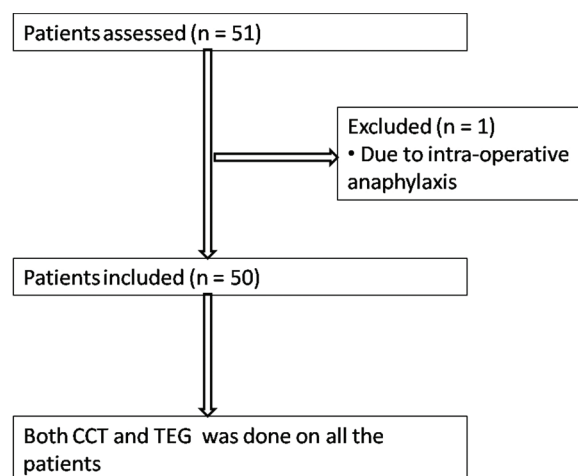
The primary objective was to evaluate the coagulation dynamics following open donor hepatectomy and compare INR with the TEG coagulation index (CI) on postoperative days (POD) 0,1,2,3,5, and 10. The secondary objectives were to study postoperative changes in fibrinogen levels, platelets, INR, PT, and aPTT and to study postoperative changes in various parameters of TEG like reaction time (R time), kinetic time (K time), alpha angle, and maximum amplitude (MA).

## METHODS

Ethics committee approval for this study (IEC/2018/65/MAO8) was provided by our institute. This trial was registered prospectively with the Clinical Trial Registry of India (CTRI/2019/05/018935). Written and informed consent was obtained from all patients. The procedure followed the guidelines laid down in Declaration of Helsinki 2013. A prospective observational study was performed from May 2019 to February 2020. Fifty-one consecutive adult living donors belonging to the American Society of Anesthesiologists (ASA) physical status class 1 and 2, aged between 18 and 50 years scheduled to undergo open donor hepatectomy for

both adult and pediatric recipients were included in this study [Figure 1]. One patient was excluded from the study because of intraoperative anaphylaxis to the intravenous antibiotic (piperacillin-tazobactam). Patients receiving antiplatelet or anticoagulant medications, preoperatively or postoperatively and not consenting were excluded from the study.

Tablet alprazolam 0.25 mg and tablet ranitidine 150 mg were administered on the night prior and the morning of surgery. On the day of surgery, in the operation room, all standard ASA monitors were attached. A large-bore 16 gauge intravenous cannula was secured in the upper limb. Under all aseptic precautions, a thoracic epidural catheter was secured at T<sub>7</sub> – T<sub>8</sub> or T<sub>8</sub> – T<sub>9</sub> level in all patients. A test dose of 3 ml of 2% lignocaine with adrenaline was administered after confirming negative aspiration for blood and cerebrospinal fluid. General anaesthesia was administered with intravenous fentanyl 1–2 µg kg<sup>-1</sup>, propofol 1–2 mg kg<sup>-1</sup>, and atracurium 0.5 mg kg<sup>-1</sup> followed by tracheal intubation. The patients were mechanically ventilated using the volume control mode with tidal volume of 6–8 ml kg<sup>-1</sup>, positive end expiratory pressure of 3–5 cm H<sub>2</sub>O, and peak inspiratory pressure less than 30 cm H<sub>2</sub>O. Anaesthesia was maintained with oxygen: air in the ratio of 30: 70 with isoflurane at 1% inhaled concentration volume as an inhalational agent in all patients. A 20 gauge radial arterial cannula was secured in the left radial artery. A 7 F triple lumen central venous catheter was inserted in the right internal jugular vein under ultrasound guidance. A bolus of 7 ml of 0.1% levobupivacaine was administered in the epidural space over 10 min. The same surgical team performed all the surgeries.



**Figure 1:** Study flow chart. CCT: Conventional coagulation test, TEG: Thromboelastography

During surgery, epidural infusion of levobupivacaine 0.1% along with 2 µg ml<sup>-1</sup> fentanyl was started at 5–7 ml h<sup>-1</sup> and the same infusion was also continued in the postoperative period for the next 5 days. Blood samples for baseline TEG and CCT (PT, INR, aPTT, fibrinogen, and platelet count) were taken immediately after induction. Unfractionated heparin in a dose of 0.5 mg kg<sup>-1</sup> was administered to all patients 3 min before hepatic artery clamping. At the completion of surgery, residual muscle paralysis was reversed with injection glycopyrrolate 0.01 mg kg<sup>-1</sup> and injection neostigmine 0.05 mg kg<sup>-1</sup>. Tracheal extubation was performed in the operation room after the patients met the extubation criteria. Sequential compression device was used in all the patients for mechanical thromboprophylaxis. Pharmacological thromboprophylaxis was not given to any of the patients. Postoperative analgesia was by patient-controlled epidural analgesia [Epidural PCA (CADD® Legacy PCA infusion model 6300) by Smith medicals]. A continuous basal infusion of 0.1% levobupivacaine with 2 µg ml<sup>-1</sup> fentanyl was started at 6 ml h<sup>-1</sup> in all patients. The lock-out interval was set at 15 min with a bolus dose of 3 ml. The maximum dose was set to three doses in an hour. Intravenous fentanyl 50 µg was used as a rescue analgesic drug. The epidural catheter was removed on POD 5, only when the INR was less than 1.5, and platelet counts were >80 × 10<sup>3</sup> cells mm<sup>3</sup>.

In the postoperative period, TEG analysis was performed for each patient on POD 0, 1, 2, 3, 5, and 10. First postoperative sample was collected 10 h after the administration of heparin. For TEG analysis, 1 ml of blood was withdrawn and immediately mixed with kaolin to accelerate clotting using thromboelastogram (TEG® 5000 Thrombelastograph® Hemostasis Analyser System, Haemonetics Corporation US) for coagulation assay as per the standard protocol and manufacturer's recommendation. Different TEG parameters (r time, k time, alpha angle, MA, and CI) were noted. The CI for whole blood was calculated as follows:

$$CI = -0.2454 \cdot r + 0.0184 \cdot k + 0.1655MA - 0.0241\alpha - 5.0220^{[7]}$$

The average values of the CI can range from -3.0 to +3.0. A value of more than +3.0 represents a hypercoagulable state, whereas a value of less than -3.0 represents a hypocoagulable state.<sup>[7]</sup>

CCT such as PT, aPTT, INR, fibrinogen, and platelet counts were also performed at the time of TEG analysis.

These tests were conducted within 4 h of sample collection. PT, INR [Neoplastin® CIPLUS, ISI value 1.30], aPTT (C.K. Prest®), and fibrinogen (Fibri-prest®) were performed on a fully automated coagulation analyser STA Compact (Diagnostica STAGO, France). Platelets were analysed on Sysmex XE Alpha-N automated haematology blood analyser. Blood products administered were also noted. Hypocoagulability was diagnosed on CCT if either INR >1.3, PT >1.5 times the baseline value or platelet count of <100 × 10<sup>3</sup> cells mm<sup>-3</sup> was present. Postoperative complications such as bleeding, DVT, and portal vein thrombosis (PVT) were also noted using the ultrasound and doppler. Complications such as epidural haematoma, epidural abscess, and lower limb weakness were also noted. DVT was treated with injection enoxaparin 60 mg two times a day for 4 weeks, PVT was managed with injection unfractionated heparin 100 IU kg<sup>-1</sup> and surgical re-exploration was as indicated. For suspected epidural haematoma, epidural infusion was immediately discontinued and neurological consultation obtained.

The sample size calculation was based on the time period duration. All patients who had met the inclusion criteria from May 2019 to February 2020 were included in the study prospectively. Fifty-one patients met the inclusion criteria. Statistical analysis was performed using Statistical Package for the Social Sciences (SPSS) software [International Business Machine (IBM) Corp, NY, USA] data editor, version 20.0]. Continuous variables were presented as mean ± standard deviation (SD) and categorical variables were presented as absolute numbers and percentages. Unpaired *t*-test was applied for continuous variable comparison. Categorical variables were measured using Fisher's exact test or Chi-square test. Continuous variables, values over time within the groups were analysed using repeated-measures analysis of variance (ANOVA) followed by Bonferroni's post-hoc testing. *P* < 0.05 was considered statistically significant.

## RESULTS

Baseline patient characteristics and operative details including age, weight, height, sex, remnant liver volume, type of hepatectomy, intraoperative blood loss, total operative time, and total fluids administered were noted [Table 1]. Significant postoperative changes occurred in the CCT and TEG [Tables 2 and 3]. The CI was calculated on different postoperative days based on the different

TEG parameters [Table 4]. Patients with increased CI had significantly decreased r time ( $P = 0.004$ ), and significantly increased MA ( $P < 0.001$ ) and alpha angle value ( $P$  value  $< 0.001$ ) when compared to the patients who had normal CI [Table 5]. There were no postoperative complications like bleeding, DVT, PVT, pulmonary embolism, epidural haematoma, epidural abscess, and lower limb weakness in any of the patients.

## DISCUSSION

The results of our study revealed a paradoxical situation wherein CCT suggested a hypocoagulable

state, but the TEG suggested a hypercoagulable state up to postoperative day 10 in 24 patients. The hypercoagulable state may predispose the patients to suffer from thrombotic complications such as hepatic artery thrombosis and PVT. In a study by Yoshiya *et al.*, the authors suggested screening of all hepatectomy patients for PVT by contrast-enhanced computed tomography on POD 7. However, this study did not include any donor patient.<sup>[8]</sup> Other studies have also suggested that the dominant prothrombotic state in patients undergoing hepatectomy might lead to other complications such as DVT and inferior vena cava thrombosis.<sup>[7,9]</sup> In a recent similar study by Raj A *et al.*, the coagulation of 80 patients who underwent right donor hepatectomy was monitored both by TEG and CCT, and all patients were found to be hypercoagulable on TEG on POD 1. This hypercoagulability gradually decreased toward POD 7.<sup>[10]</sup> In contrast to these findings, in our study, we found hypercoagulability in only 28% of the patients on TEG on POD 1. This hypercoagulability gradually increased toward POD 10 and 48% of the patients were hypercoagulable on POD 10. Many centres are using TEG to monitor the coagulation in patients undergoing open donor hepatectomy. However, the timing, duration, and frequency of doing TEG in the postoperative period are still not clear. Each center follows its own protocol and literature search does not suggest any recommendations on the monitoring of coagulation in donor patients. From the findings of our study, we recommend that

**Table 1: Patient characteristics**

Total Donors (n)	50
Age (years)	32.5±10.1
Weight (kg)	62.4±7.3
Height (cm)	163.3±7.8
BMI (kg/m <sup>2</sup> )	23.7±2.7
Sex, m/f	23/27
Duration of surgery (minutes)	552.0±70.5
Graft Volume (gm)	658.5±154.6
Remnant Liver Volume (gm)	524.2±130.2
Remnant volume/Body weight ratio	0.84±0.21
Intraoperative Blood Loss (ml)	401.5±244.7
Fluid given intraoperatively (l)	5.49±1.05
Surgery (n)	
Left hepatectomy	7
Left lateral hepatectomy	1
Right hepatectomy	42

Demographic variables, Mean±SD. n: Number, BMI: Body mass index, m/f: Male/female

**Table 2: Changes in conventional coagulation parameters at different time-points**

	PT (seconds) (Mean±SD)	INR (Mean±SD)	aPTT (seconds) (Mean±SD)	PlateletCount (*10 <sup>9</sup> /l) (Mean±SD)	Fibrinogen (mg/dl) (Mean±SD)
Preoperative	12.40±1.06	1.15±0.11	22.76±1.13	217.84±42.0	288.90±50.97
Post Operative	14.878±2.31*	1.42±0.20*	23.80±1.52*	192.36±50.92**	249.12±51.04*
POD 1	17.62±2.28*	1.65±0.22*	24.38±1.44*	165.24±31.95*	219.12±63.04*
POD 2	18.69±2.95*	1.74±0.33*	24.98±1.53*	154.76±34.96*	268.47±108.61
POD 3	16.55±2.46*	1.55±0.28*	23.88±1.20*	173.40±35.72*	301.38±85.33
POD 5	13.88±1.40*	1.30±0.13*	23.29±1.12	200.52±34.74	326.89±100.81
POD 10	12.71±0.68	1.18±0.07	22.63±0.66	239.06±49.03	320.84±75.26

\*  $< 0.001$ , \*\* = 0.001. POD: Postoperative day, PT: Prothrombin time, INR: International normalised ratio, aPTT: Activated partial thromboplastin time, SD: Standard deviation

**Table 3: Changes in thromboelastography parameters at different time -points**

	R time (minutes) (Mean±SD)	K time (minutes) (Mean±SD)	Alpha angle (degree) (Mean±SD)	Maximum amplitude (degree) (Mean±SD)
Preoperative	6.14±1.24	2.51±0.98	55.50±4.48	65.65±5.99
Postoperative	6.01±1.92	3.09±1.24	56.67±10.43	65.92±6.60
POD 1	6.00±3.79	2.82±1.21	58.79±10.63	67.32±9.79
POD 2	5.51±1.90	2.71±0.94	59.28±8.94	67.42±8.08
POD 3	5.54±1.77	2.79±0.97	62.55±6.94	67.73±8.08
POD 5	4.42±1.68	4.07±1.82	59.82±6.76	68.05±8.26
POD 10	5.07±1.42	3.27±0.98	62.11±6.05	67.22±7.11

POD: Postoperative day, R time: Reaction time, K time: Kinetic time, SD: Standard deviation

Table 4: Coagulation status in all subjects at different time points

	Pre-operative	POD0	POD1	POD2	POD3	POD5	POD10
Hypocoagulable (CI < -3) n (%)	0	0	0	0	0	0	0
Normocoagulable (CI -3 to+3) n(%)	50 (100)	36 (72)	31 (62)	35 (70)	27 (54)	29 (58)	26 (52)
Hypercoagulable (CI>3) n (%)	0	14 (28)	19 (38)	15 (30)	23 (46)	21 (42)	24 (48)
Normocoagulable (INR<1.5) n (%)	50 (10)	39 (78)	11 (22)	11 (22)	23 (46)	45 (90)	50 (100)
Hypocoagulable (INR≥1.5) n (%)	0	11 (22)	39 (78)	39 (78)	27 (54)	5 (10)	0

CI: Coagulation index, POD: Post operative day, INR: International normalised ratio, n: Number

Table 5: Comparison of various parameters between hypercoagulable and normocoagulable patients

	Normocoagulable (n=26) (Mean±SD)	Hypercoagulable (n=24) (Mean±SD)	P
Age (years)	31.00±9.65	34.29±10.52	0.217
BMI (kg/m <sup>2</sup> )	23.41±2.62	23.44±2.43	0.741
Remnant (%)	45.69±11.56	43.35±11.15	0.317
Intraoperative blood loss (ml)	447.12±329.91	352.08±66.72	0.208
Duration of surgery (minutes)	551.17±73.36	554.17±69.02	0.682
Platelets(*10 <sup>9</sup> /l)	232.84±43.60	245.80±54.44	0.355
INR	1.17±0.08	1.20±0.07	0.244
PT (seconds)	12.63±0.69	12.86±0.69	0.120
aPTT (seconds)	22.42±0.58	22.85±0.68	0.708
Fibrinogen (mg/dl)	331.35±80.49	309.46±69.02	0.309
R time (minutes)	5.62±1.31	4.48±1.34	0.004
K time (minutes)	3.29±0.82	3.24±1.14	0.762
Alfa angle (degree)	58.86±5.33	65.62±4.75	< 0.001
Maximum amplitude (degree)	62.37±4.92	72.47±5.12	< 0.001

BMI: Body mass index, POD: Postoperative day, INR: International normalised ratio, PT: Prothrombin time, aPTT: Activated partial thromboplastin time, R: Reaction time, K time: Kinetic time, SD: Standard deviation

TEG should be done routinely for all these patients until it becomes normal in the post-operative period. Also, those having hypercoagulable TEG at the time of discharge may be given thromboprophylaxis for a longer duration. However, we need larger randomised controlled trials on this topic.

In another study, Cerutti *et al.* evaluated the utility of TEG in donor hepatectomy patients. They included 10 prospective living liver donors and evaluated the coagulation profile by platelet count, PT, INR, aPTT, and TEG on days 1,3,5, and 10 postoperatively. They found that despite a decrease in platelet counts, an increase in PT, INR, and normal aPTT values, TEG showed hypercoagulability in four subjects on day 5 and in six subjects on POD 10. One donor with hypercoagulable TEG on day 5 also had DVT on day 8.<sup>[7]</sup> This raises another important question of using

anticoagulation during the postoperative period. This subject is controversial in donor hepatectomy patients. The duration and the timing of anticoagulation are also not clear in these patients. Literature search did not reveal any recommendation on thromboprophylaxis for healthy patients undergoing donor hepatectomy.

In donor hepatectomy, chemical thromboprophylaxis is still not widely accepted, owing to the fear of bleeding from the transected liver surface along with the hepatic insufficiency caused by the parenchymal transection. The rapid change in coagulation status after hepatectomy makes it even more difficult for the treating physician to decide when to start the chemical thromboprophylaxis.

In a study by Kamei *et al.*, it was reported that the levels of protein S and C are decreased in patients



undergoing donor hepatectomy. Based on this, they suggested implementation of thrombophilia testing guided venous thromboprophylaxis in patients undergoing donor hepatectomy. In their study, postoperative intravenous heparin was given to the patients who had decreased protein C and S levels until they were ambulated.<sup>[11]</sup> Studies by Reddy *et al.* and Melloul *et al.* found a significantly decreased incidence of pulmonary embolism in the patients receiving pharmacological thromboprophylaxis either with unfractionated heparin or enoxaparin. These authors have suggested a more aggressive thromboprophylaxis in patients with body mass index (BMI) >25 kg m<sup>-2</sup>, patients undergoing major liver resection, and normal liver parenchyma groups.<sup>[12,13]</sup> However, these studies were performed on a non-healthy population undergoing hepatectomy for primary liver disease such as hepatocellular carcinoma.

None of the patients in our study demonstrated hypocoagulability on any of the PODs on TEG. The paradox can be explained by the fact that hepatectomy leads to a decrease in both pro and anticoagulant factors. A large amount of factor VIII, von Willebrand factor and tissue factor is released into the circulation from the cut surface of the liver. Rapid liver regeneration, along with the bone marrow response explains the quick return of PT, INR, and platelet values to normal; however, the level of anticoagulant continues to be suppressed, resulting in the hypercoagulable state.<sup>[7]</sup> CCT basically only measures the activity of pro-coagulants, while TEG measures the holistic status of the coagulation by measuring the activity of both pro and anticoagulants. Therefore, in our study, although the INR of many patients was elevated in the postoperative period, none demonstrated an increased risk of bleeding as measured by the TEG.

Based on the findings of our study, we recommend that the decision to start pharmacological thromboprophylaxis should be based on the TEG findings and not on the INR. Similarly, the total duration of thromboprophylaxis can also be decided based on the status of the TEG.

The limitation of our study is that it is difficult to conclude when the coagulation of these patients actually became normal in the postoperative period as we followed these patients for the first ten PODs.

## CONCLUSION

To conclude, hypercoagulability after donor hepatectomy is common. TEG shows hypercoagulability and does not show any hypocoagulability as suggested by the CCT. In patients undergoing donor hepatectomy, CCT may not reflect the actual coagulation status and viscoelastic tests such as TEG should be performed to assess the real picture of coagulation dynamics after surgery. However, larger studies on more patients are suggested to consolidate our study findings and to suggest appropriate management.

### Declaration of patient consent

The authors certify that they have obtained all appropriate patient consent forms. In the form the patient(s) has/have given his/her/their consent for his/her/their images and other clinical information to be reported in the journal. The patients understand that their names and initials will not be published and due efforts will be made to conceal their identity, but anonymity cannot be guaranteed.

### Financial support and sponsorship

Nil.

### Conflicts of interest

There are no conflicts of interest.

## REFERENCES

1. Pandit RA. Brain death and organ donation in India. *Indian J Anaesth* 2017;61:949-51.
2. Williams R, Alisa A, Karani J, Rela M, Heaton N. Living related adult-to-adult liver transplantation: Meeting the donor shortage. *Antiviral Res* 2001;52:217-23.
3. Singh SA, Vivekananthan P, Sharma A, Sharma S, Bharathy KG. Retrospective analysis of post-operative coagulopathy after major hepatic resection at a tertiary care centre in Northern India. *Indian J Anaesth* 2017;61:575-80.
4. Bezeaud A, Denninger MH, Dondero F, Saada V, Venisse L, Huisse MG, *et al.* Hypercoagulability after partial liver resection. *ThrombHaemost* 2007;98:1252-6.
5. Mallett SV, Sugavanam A, Krzanicki DA, Patel S, Broomhead RH, Davidson BR, *et al.* Alterations in coagulation following major liver resection. *Anaesthesia* 2016;71:657-68.
6. Potze W, Alkozai EM, Adelmeijer J, Porte RJ, Lisman T. Hypercoagulability following major partial liver resection-detected by thrombomodulin-modified thrombin generation testing. *Aliment Pharmacol Ther* 2015;41:189-98.
7. Cerutti E, Stratta C, Romagnoli R, Schellino MM, Skurzak S, Rizzetto M, *et al.* Thromboelastogram monitoring in the perioperative period of hepatectomy for adult living liver donation. *Liver Transpl* 2004;10:289-94.
8. Yoshiya S, Shirabe K, Nakagawara H, Soejima Y, Yoshizumi T, Ikegami T, *et al.* Portal vein thrombosis after hepatectomy. *World J Surg* 2014;38:1491-7.
9. Kobayashi S-I, Yokoyama Y, Matsushita T, Kainuma M, Ebata T, Igami T, *et al.* Increased von Willebrand Factor to

- ADAMTS13 ratio as a predictor of thrombotic complications following a major hepatectomy. *Arch Surg* 2012;147:909–17.
10. Raj A, Shankar V, Singhal S, Dhar P, Krishnan L, Goyal N, *et al.* Thromboelastogram demonstrates significant hypercoagulability in patients undergoing right donor hepatectomy – A prospective single center analysis. *Int J Transplant Resp Med* 2020;6:050. doi: 10.23937/ 2572-4045. 1510050.
  11. Kamei H, Onishi Y, Kurata N, Ishigami M, Ogura Y. Donor selection and prophylactic strategy for venous thromboembolic events in living donors of liver transplantation based on results of thrombophilia screening Tests. *Ann Transplant* 2017;22:409–16.
  12. Reddy SK, Turley RS, Barbas AS, Steel JL, Tsung A, Marsh JW, *et al.* Post-operative pharmacologic thromboprophylaxis after major hepatectomy: Does peripheral venous thromboembolism prevention outweigh bleeding risks? *J Gastrointest Surg* 2011;15:1602–10.
  13. Melloul E, Dondéro F, Vilgrain V, Raptis DA, Paugam-Burtz C, Belghiti J. Pulmonary embolism after elective liver resection: A prospective analysis of risk factors. *J Hepatol* 2012;57:1268–75.