Logistic Coordination in Pediatric Liver Transplantation: Criteria for Optimization

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ABSTRACT

Introduction. Logistic organization of the transplantation coordination process aims to synchronize the recovery and recipient team and to reduce to a minimum the graft's cold ischemia time (CIT), which, in turn, is known, to have deleterious effects on the graft and recipient, if prolonged. To determine whether variables influencing the different steps in the coordination process might allow for reducing CIT, this study aimed to analyze these variables.

Patients and methods. Retrospective analysis of 61 pediatric liver transplantations from 2006 to 2015 in the Geneva University Hospitals.

Results. Length of donor hepatectomy was increased for split grafts ($P < .0001$). Length of recipient hepatectomy was longer in the case of previous surgery ($P = .06$). The recipient team waiting time for the graft was longer for split grafts ($P = .01$). The graft waiting time at the recipient site was longer for whole grafts ($P = .0005$) and increased recipient weight ($P = .03$). The graft waiting time at the donor site was doubled in the case of recovery of organs after the liver by the same team ($P = .007$). The graft waiting time at the donor and recipient site not surprisingly increased the CIT ($P = .007$ and $< .0001$, respectively).

Conclusion. CIT depends on waiting times during the entire coordination process, which largely depends on the estimation of hepatectomy lengths. A more accurate estimation, considering graft type and recipient's previous surgery and weight, might allow for decreasing CIT and consequently improve outcomes after pediatric liver transplantation.

THE success of liver transplantation (LT) depends on many surgical and medical factors [1]. One of those is cold ischemia time (CIT), which negatively influences outcome if prolonged. Indeed, a prolonged CIT beyond 360 to 480 minutes has been shown to lead to an increased rate of graft dysfunction [2–5]; further, a decreased patient survival after 1, 5, and 10 years were reported when CIT was beyond 390 minutes [5–7]. CIT above 400 to 600 minutes has also been shown to increase the incidence of complications, such as early and late hepatic artery thrombosis and acute postoperative infections, and to increase the development of portal fibrosis [8–12].

Logistic organization of the recovery and transplantation process by a transplant coordinator not only aims to achieve a smooth course of this complex management but also to reduce to a minimum the graft's CIT and, secondarily, the length of surgery in the recipient. In fact, prolonged recipient surgery time is also known to increase the risk of complications. It has been shown that duration beyond 500 to 600 minutes increases biliary leaks, the incidence of short- and medium-term infections, and, likewise, hepatic artery thrombosis [12–16]. Further, prolonged surgery time also appears to be a risk factor for increased mortality [11,16].

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The transplant coordinator plays a crucial role on the day of LT [17] by keeping the CIT to a minimum by synchronizing the organ recovery and recipient teams, and thus indirectly improving the outcome of organ transplantations. As an example, the different steps of the coordination process of pediatric LT in our institution are summarized in Fig 1. The proper conduct of the transplantation process strongly depends on the correct estimation of the lengths of its constituting steps. These estimations allow the coordinator to plan the incision time of the recipient and to synchronize the beginning of the implantation with the end of the back table, corresponding to the final moment of the graft preparation after its arrival.

To date, studies of causality between the coordination process and CIT are virtually nonexistent. This work aims to analyze the factors of the logistic coordination process influencing CIT in pediatric LT and to evaluate its efficiency in our center in Geneva, the only center accredited for this procedure in Switzerland. A suboptimal coordination is revealed by the graft's waiting times at the donor or recipient site, as well as the recipient team's waiting time in the recipient's operation room. Each one reflects an incorrect estimation of the lengths of the different procedural steps. We hypothesized that multiple explanatory variables affect the estimated lengths. Identifying significant variables might help to positively influence the coordination process and thus to reduce CIT and length of surgery in the recipient.

MATERIAL AND METHODS

Study Population

A retrospective analysis was performed on pediatric patients, aged 0 to 18 years, having undergone LT between January 2006 and December 2015 at the Geneva University Hospitals. Donors were exclusively deceased brain donors, and overweight donors were not chosen during this time period, thus body mass index was always low, the median being 22.1 kg/m^2. Of note, the rather small surgical and coordinator team was remarkably consistent and stable, and changes in practice were considered minimal. Data were extracted from general institutional and individual patient databases.

Exclusion criteria were the following: LT with a graft from a living donor, multiple-organ transplantation, ex situ liver reduction, LT with a monosegment graft, and cases where a biopsy of the graft was performed at the recipient site because of the additional delay for implantation. After initial analysis, 2 further cases were excluded, 1 because of excessive missing data and another with excessively prolonged recipient team's waiting time because of an exceptional logistic situation caused by a breach in the transplant coordination protocol.

The study population is described in Fig 2. The study was approved by the local ethics committee (CER 11-01OR/MATPED 11-004R).

Variables and Outcome Assessment

CIT, lengths of surgeries, waiting times, and other expressions used in this study are defined in Table 1. Variables supposed to explain these time periods were called explanatory variables: graft type (whole, split), recipient weight, organs recovered before liver (heart, lung, or both), organs recovered after liver (kidney, pancreas, or both), indication for LT surgery (biliary atresia, other: other cholestatic disease, acute liver failure, neoplasia, or metabolic disease), and previous surgery (re-LT, status post Kasai). Since the journey time from the donor to the recipient site was considered nongeneralizable (weather, traffic, etc), this parameter was not included in the analysis. Of note, since the distance from the donor hospital to our institution is always very small in Switzerland compared with other countries, the variation can be considered as minimal.

All cases were reviewed with the recipient surgeon who participated in most of the procedures. When the explicit length of the recipient team's waiting time was missing in the documentation, it was deduced from the regularity of the cardiac rhythm of the recipient during surgery when there was no surgical action; this analysis was performed in collaboration with the anesthesiologists, the main recipient's surgeon, and the operative report. To assure the correctness of the method, it was also applied in patients having the real waiting time in our datasets, confirming that the estimated time using the above method corresponded to the real time. When the removal time of the recipient liver was missing, it was assumed that the liver had been removed from the abdomen 15 minutes before graft implantation; this assumption was made together with the main recipient's surgeon and based on the analysis of all documents available, such as anesthesia, scrub nurses' notes, and operative notes. If the length of donor hepatectomy was missing, it was estimated with the expertise of the transplant coordinator and consulting the coordination chart.

Statistics

Student t test or χ^2 test were used, respectively, in the descriptive analysis to compare means ($\pm$ standard deviation) of waiting times, lengths of surgeries, and CIT, according to the explanatory variables and waiting times. Wilcoxon rank sum test was used for the recipient team's waiting time, as a nonparametric alternative to the t test. Univariate linear and logistic regressions were applied for the association between explanatory variables and waiting times, lengths of surgeries, and CIT. Secondarily, multivariate linear and logistic regressions were done to determine the most decisive of non-intercorrelated, clinically meaningful, and sufficiently significant factors in the univariate analysis ($P \leq .1$). All statistical tests were 2-sided, and a P value $\leq .05$ was considered statistically significant. Statistical analyses were carried out with SAS version 9.2 for Windows (SAS Institute, Inc, Cary, NC, United States).

RESULTS

Table 2 details characteristics of the study population. Table 3 describes and compares variables. Table 4 shows univariate and multivariate regression analysis of the influence of explanatory variables on waiting times, intervention lengths, and CIT. Results are graphically summarized in Fig 3.

In the following, we detail the results represented in the tables and figure.

Lengths of Hepatectomies

The length of donor hepatectomy was significantly longer for split graft LT in the univariate analysis (β coefficient (β) = +152.7 minutes, $P < .0001$) and remained significant in the multivariate model, adjusting for recovering organs before the liver. The length of recipient hepatectomy showed a trend to being increased in the case of previous

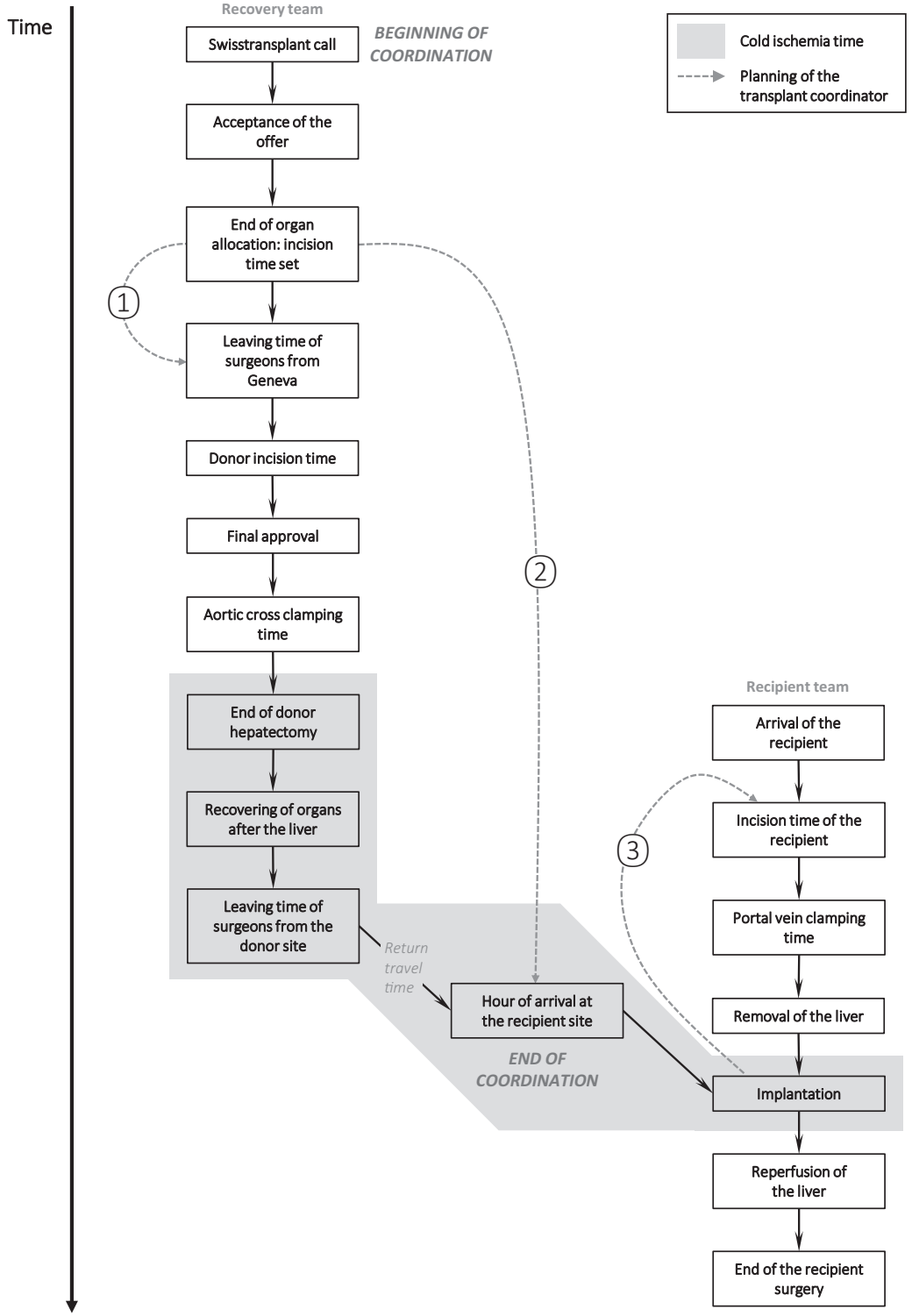

Fig 1. Different steps of the coordination process of pediatric liver transplantation in our institution. 1. The leaving time of the recovery team from Geneva is determined according to the travel time. 2. The hour of the graft arrival is determined according to i. the estimated donor hepatectomy duration, ii. which organs need to be recovered after the liver, and iii. the return travel duration. 3. The incision time of the recipient is determined considering principally the estimated recipient hepatectomy duration. In gray: the cold ischemia time corresponds to the time between the explantation of the liver from the donor and its implantation in the recipient.

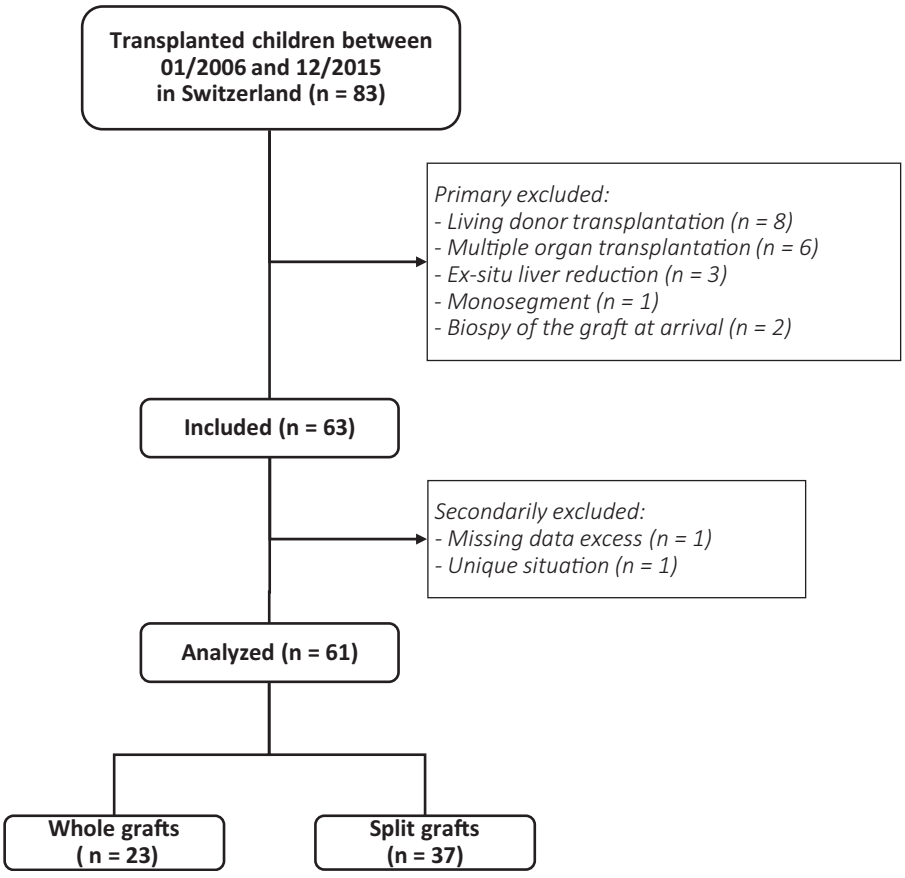

Fig 2. Study population.

surgery ($\beta = +41$ minutes, $P = .06$) in both univariate and multivariate analysis, adjusting for graft type.

The surgeon's experience played a major role in the duration of hepatectomies. This was particularly true for donor hepatectomies: junior surgeons were more susceptible to realize whole liver hepatectomies and tended to overestimate their operating time, which in turn had an impact on waiting time (see Fig 3). Senior surgeons, mostly performing the split surgery, tended to underestimate their operating time, which in turn resulted in a notable increase in the waiting time of the recipient team. On the other hand, the recipient's hepatectomies were always achieved by the same pediatric surgical team and thus didn't allow for comparison.

Table 1. Definition of Different Expressions Used in This Study

Cold ischemia time	Duration between cross clamping of the donor aorta and the beginning of the graft implantation in the recipient.
Length of surgery in the recipient	Duration between incision time and end of skin closure.
Length of hepatectomy (donor and recipient)	Duration between incision time and liver removal. Donor: all split grafts were prepared in situ. Recipient: the recipient team's waiting time was not included. In case of missing removal time, it was defined as time between beginning of implantation and incision time minus 15 minutes.
Graft's waiting time at the donor site	Duration between the end of donor hepatectomy and the departure of surgeons from the donor site. No waiting time has been defined as $\leq$ 15 minutes.
Graft's waiting time at the recipient site	Duration between the end of the final graft preparation on the back table and the beginning of the graft implantation. No waiting time has been defined as $\leq$ 10 minutes.
Recipient team's waiting time	Duration between the time when the native recipient liver is ready for removal and the beginning of implantation, when the graft is not available.
Cross clamping time	Moment of the occlusion of the donor aorta and beginning of the perfusion of preservation fluid, which initiates organ recovery
Implantation start	Time when the liver graft is placed in the recipient's abdomen

Table 2. Characteristics of the Study Population

Groups	Total	Subgroups	n (%)	Mean (± SD)	Median (IQR)
Age, mo	61			67 (± 68)	29 (12-131)
Sex	61	Male	36 (59)		
		Female	25 (41)		
Weight, kg	61			21.96 (± 18.25)	13 (8.3-36.8)
		< 10 kg	23 (38)		
		≥ 10 kg	38 (62)		
Indications for LT	61	Biliary atresia	28 (46)		
		Other cholestatic disease	13 (21)		
		Acute liver failure	7 (11)		
		Neoplasia	5 (8)		
		Metabolic disease	7 (11)		
Previous surgery	61	Yes	31 (51)		
		No	30 (49)		
Donor BMI, kg/m^2	60			21.1 (± 4.5)	22.1 (16.8-24.5)
Place of graft recovery	61	Switzerland	42 (69)		
		Abroad	19 (31)		
Graft type	61	Split	37 (61)		
		Whole	24 (39)		
Organs recovered before liver	61	None	18 (30)		
		Heart	14 (23)		
		Heart-lungs	24 (39)		
		Lungs	5 (8)		
Organs recovered after liver	61	None	19 (31)		
		Kidneys	20 (32)		
		Kidneys-pancreas	19 (31)		
		Kidneys-intestines	1 (2)		
		Kidneys-pancreas-intestines	2 (3)		
Cold ischemia time, min	61			323 (± 82)	315 (273-372)
		< 360	43 (70)		
		> 360	18 (30)		
Length of surgery in the recipient, min	59			579 (± 127)	559 (480-675)
		< 600	36 (61)		
		> 600	23 (39)		
Recipient team's waiting time, min*	61				0 (0-38)
		Waiting time	18 (30)		60 (45-130)
		No waiting time	43 (70)		0 (NA†)
Graft's waiting time at the recipient site, min*	61				47 (15-83)
		Waiting time	47 (77)		60 (4-90)
		No waiting time	14 (33)		0 (0-5)
Graft's waiting time at the donor site, min	46			60 (± 33)	55 (40-72)
		Waiting time	42 (91)	65 (± 31)	58 (45-72)
		No waiting time	4 (9)	9 (± 6)	10 (3-14)
Length of donor hepatectomy, min	44			307 (± 100)	304 (211-375)
Length of recipient hepatectomy, min	61			218 (± 87)	211 (150-282)

Abbreviations: BMI, body mass index; IQR, interquartile range; LT, liver transplant; SD, standard deviation.
*Skewed distribution.
†NA, not applicable for the interquartile range.

Lengths of Waiting Times

In the case of split graft LT, the recipient team waited significantly longer for the graft (odds ratio 8.4, $P = .009$) in univariate and multivariate analysis, adjusting for recovery of organs before and after the liver. Thus, there was also significantly less graft waiting time at the recipient site (odds ratio 0.96, $P = .001$) in both univariate and multivariate analysis when the recipient team waited. The graft waited significantly longer at the recipient site in case of whole graft LTs ($\beta = +37.1$ minutes, $P = .0005$) and in case of increased recipient weight (ie, > 10 kg, $\beta = +31.3$, $P = .03$) but obviously waited significantly less in the case of the recipient team waiting time ($\beta = -52.5$ minutes); the effect of graft type remained significant in the multivariate model when adjusting for previous surgery. The graft waiting time at the donor site was significantly longer if other organs were recovered after the liver ($\beta = +34.2$ minutes, $P = .007$). Specifically, the liver graft waited 21 minutes for additional nephrectomy and 49 minutes for additional nephrectomy and pancreatectomy.

Table 3. Description and Comparison of Waiting Times, Lengths of Surgeries, and CIT According to Explicative Variables (Mean ± SD and Proportions)

Independent Variables	Sub-groups	Recipient Team's Waiting Time (% > 0 vs % = 0)	*P* Value*	Recipient Team's Waiting Time	*P* Value†	Graft's Waiting Time at Recipient Site	*P* Value‡	Graft's Waiting Time at Donor Site	*P* Value§	Length of Donor Hepatectomy	*P* Value§	Length of Recipient Hepatectomy	*P* Value§	Length of Surgery in the Recipient	*P* Value§	CIT	*P* Value§
Liver graft type	Whole	8.3/91.7	.004	6.9 (±24.2)	.005	80.7 (±49.0)	.0001			213.4 (±49.1)	< .0001	198.5 (±70.5)	*NS*	523.6 (±99.2)	.005	359.4 (±65.2)	.005
	Split	43.2/56.8		38.4 (±58.9)		43.6 (±65.3)				366.0 (±75.1)		230.8 (±94.2)		616.2 (±130.6)		300.0 (±84.5)	
Weight	≥ 10 kg					70.0 (±70.2)	*.03*					220.9 (±92.9)	*NS*			345.9 (±85.0)	*.005*
	< 10 kg					38.7 (±38.4)						213.5 (±76.5)				286.1 (±63.1)	
Indication	Other					49.7 (±41.6)	*NS*					208.8 (±90.4)	*NS*			314.4 (±79.9)	*NS*
	Biliary atresia					68.1 (±79.0)						229.0 (±82.0)				334.0 (±85.2)	
Previous surgery	No					47.0 (±39.6)	*NS*					197.3 (±82.6)	*.06*			305.9 (±81.4)	NS
	Yes					69.0 (±76.6)						238.3 (±86.7)				340.4 (±80.8)	
Organs recovered before liver	No	33.3/66.7	*NS*	19.6 (±32.3)	*NS*					293.8 (±90.6)	*NS*	229.3 (±97.1)	*NS*	608.4 (±115.5)	*NS*		
	Yes	27.9/72.1		28.7 (±56.5)						311.5 (±103.7)		213.4 (±82.5)		566.5 (±130.1)			
Organs recovered after liver	No	26.3/73.7	*NS*	17.1 (±37.8)	*NS*			31.9 (±18.7)	*.007*			212.7 (±81.8)	*NS*	561.7 (±108.0)	*NS*	321.0 (±62.6)	*NS*
	Yes	31.0/69.0		30.1 (±55.2)				66.0 (±32.7)				220.5 (±89.5)		585.9 (±134.4)		324.5 (±90.4)	
Graft's waiting time at donor site	No wait	50.0/50.0	*NS*	45.0 (±71.4)	*NS*									632.0 (±149.6)	*NS*	238.3 (±23.6)	*.03*
	Wait	31.0/69.0		30.1 (±55.2)										574.1 (±130.5)		332.0 (±84.7)	
Graft's waiting time at recipient site	No wait	71.4/28.6	< *.0001*	61.8 (±69.7)	*.03*											243.6 (±60.0)	< *.0001*
	Wait	17.0/83.0		15.4 (±38.0)												347.2 (±72.8)	
Recipient team's waiting time	No wait					73.7 (±66.2)	< *.0001*							567.1 (±127.1)	*NS*	342.2 (±79.7)	*.005*
	Wait					21.2 (±24.1)								609.2 (±123.5)		278.6 (±72.0)	

Abbreviations: CIT, cold ischemia time; SD, standard deviation.
*χ^2test for proportions of waiting time > 0 minutes vs waiting time = 0 minutes within categories of the independent variables.
†Mann-Whitney/Wilcoxon rank sum analysis, as a nonparametric alternative to the *t* test.
‡Square root transformation of the variable "graft's waiting time at recipient site," to achieve normality for parametric testing (the original values [mean ± SD] are shown in the table).
§*t* test.

Table 4. Univariate and Multivariate (in Bold, Second Line) Regressions of the Influence of Explicative Variables on Waiting Times, Interventions Durations, and CIT

Explanatory Variables	Subgroups and (n)	Recipient Team's Waiting Time > 0 Min vs 0 Min*	Graft's Waiting Time at Recipient Site†	Graft's Waiting Time at Donor Site	Length of Donor hepatectomy	Length of recipient Hepatectomy	Length of Surgery in the Recipient	CIT
		Waiting Times			Intervention Lengths			
According to Explanatory Variables								
		OR and *P* Values	ß Coefficient and *P* Values			ß Coefficient and *P* Values		
Liver graft type	Split vs whole	8.4, $P = .009$	−37.1, $P = .0005$		152.7, $P < .0001$	32.3, $P = .16$	92.6, $P = .005$	−59.4, $P = .005$
		8.4, $P = .01$	−37.4, $P = .0005$		157.7, $P < .0001$	31.7, $P = .16$	85.0, $P = .01$	−61.1, $P = .004$
Weight	< 10 kg vs ≥ 10 kg		−31.3, $P = .03$			−7.4, $P = .75$		−59.8, $P = .005$
Indication	BA vs other		18.4, $P = .4$			20.2, $P = .37$		19.6, $P = .36$
Previous surgery	Yes vs no		22.0, $P = .32$			41.0, $P = .06$		34.5, $P = .10$
			22.5, $P = .25$			40.6, $P = .06$		35.5, $P = .08$
Organs recovered before liver	Yes vs no	0.8, $P = .67$			17.6, $P = .62$	−15.9, $P = .52$	−42.0, $P = .25$	
		1.0, $P = .99$			*41.5, P = .08*		−36.0, $P = .33$	
Organs recovered after liver	Yes vs no	1.3, $P = .71$		34.2, $P = .007$		7.8, $P = .75$	24.2, $P = .50$	3.5, $P = .88$
		1.0, $P = .96$					23.8, $P = .52$	11.5, $P = .59$
According to Waiting Times								
Graft's waiting time at donor site	Continuous	1.0, $P = .68$					−0.57, $P = .34$	0.52, $P = .18$
		1.0, $P = .65$					−0.62, $P = .31$	0.69, $P = .007$
Graft's waiting time at recipient site	Continuous	0.96, $P = .001$						1.0, $P < .0001$
		0.96, $P = .004$						1.0, $P < .0001$
Recipient team's waiting time	Wait vs none		−52.5, $P < .0001$				42.0, $P = .26$	−63.6, $P = .005$
							36.1, $P = .42$	−12.3, $P = .51$

The β-coefficient represents the differences of means between groups or for an increase of 1 unit in minutes when the explanatory variable is continuous.
Abbrevaitions: BA, biliary atresia; CIT, cold ischemia time; OR, odds ratio.
*Logistic regression for waiting time > 0 minutes vs waiting time = 0 minutes.
†Square root transformation of the variable "graft's waiting time at recipient site" to achieve normality for parametric testing (the original values [beta estimates] are shown in the table).

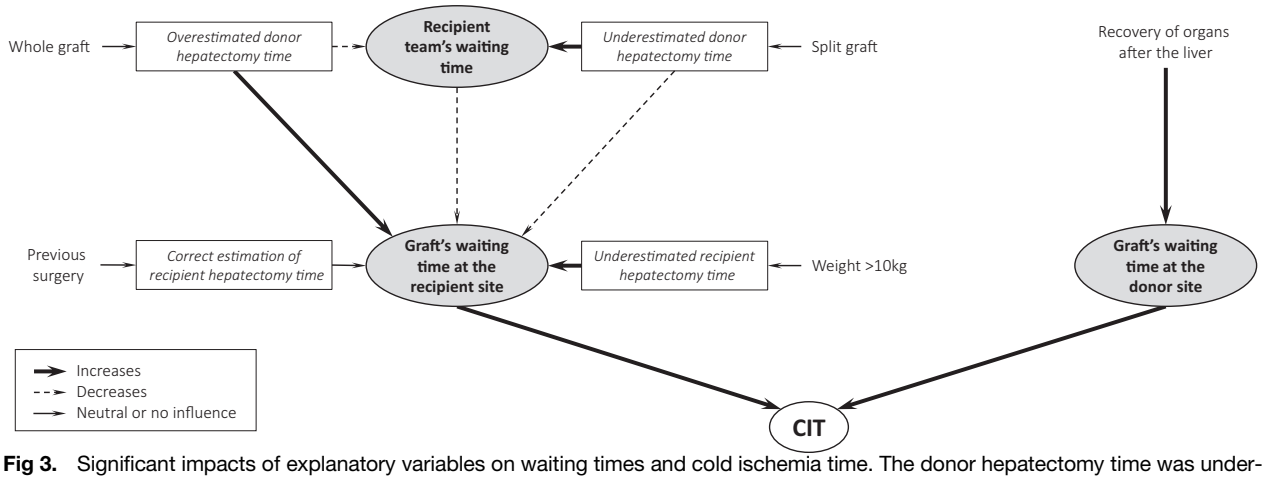

Fig 3. Significant impacts of explanatory variables on waiting times and cold ischemia time. The donor hepatectomy time was underestimated in case of split grafts, leading to an increased recipient team waiting time, leading to a reduction of graft waiting time at the recipient site. The donor hepatectomy time was overestimated for whole liver grafts, decreasing the recipient team waiting time, yet leading to an increased graft waiting time at the recipient site. Previous surgery increased recipient hepatectomy time but, since correctly considered in our center, did not increase graft waiting time. Recipient hepatectomy time was underestimated in higher recipients weights, increasing the graft waiting time at the recipient site. Recovery of organs after the liver increased the graft waiting time at the donor site. In summary, cold ischemia time significantly increased with increased graft waiting times at any place. CIT, cold ischemia time.

CIT and Length of Recipient Surgery

CIT was significantly longer for whole graft LTs ($\beta = +59.4$ minutes, $P = .005$) for the higher recipient weight group (> 10 kg, $\beta = +59.8$ minutes, $P = .005$) and in the case of graft waiting time at the recipient site ($\beta = +1.0$ min/min of waiting time). On the other hand, CIT was significantly lower in the case of recipient team waiting time ($\beta = -63.6$ minutes, $P = .005$). After adjusting for graft type, previous surgery, and organs recovery after the liver, CIT remained significantly shorter for split graft LT. After including all the waiting times in the multivariate analyses, graft waiting time at the donor site appeared as a factor influencing CIT, while recipient team waiting time lost its influence. No change was observed regarding graft waiting time at the recipient site.

Finally, length of surgery in the recipient was significantly higher for split graft LT ($\beta = +92.6$ minutes, $P = .005$) and remained influenced by graft type after adjusting simultaneously for organ recovery before and after the liver.

DISCUSSION

In this study, we investigated the determinants of the coordination process of pediatric LT and evaluated its efficiency in Switzerland. As graphically summarized in Fig 3, we found that lengths of donor and recipient hepatectomies are the key parameters to estimate for a seamless LT coordination, that is, a coordination without waiting times, neither of the graft nor of the recipient. Waiting times unnecessarily increase CIT and, according to the literature, negatively influence the outcome of LT.

Donor Hepatectomy

We showed that graft type significantly influenced the length of donor hepatectomy. Since all split grafts LT were prepared in situ, this obviously increased the length of donor hepatectomy. Yet the correct time was apparently not well estimated and the recovery team often seemed to *under*estimate the length of donor hepatectomy in the case of in situ splitting, notably always done by senior surgeons. As a result, the transplant coordinator planned a too early incision time in the recipient and thus the underestimated recovery time induced an increased recipient team's waiting time, with consequently an increased length of surgery in the recipient. Conversely, in the case of whole graft recoveries, the recovery team, mainly junior surgeons, tended to *over*estimate the length of donor hepatectomy and therefore the transplant coordinator scheduled a later incision time in the recipient. Thus, the graft waited at the recipient site, with therefore an increase of CIT. When the recovery team realizes that it worked too quickly, an idea would be to delay the cross clamping, but it seems illusory that all the recovery teams on site would agree to it.

In the case of the donor surgery, anatomic variations can be important and could increase hepatectomy time. These days, the surgeons are often helped by computed tomography scans to evaluate the donor before surgery, allowing for the anticipation of possible anatomic variations and thus a better estimation of hepatectomy duration.

Recipient Hepatectomy

The length of recipient hepatectomy was significantly influenced by the history of previous surgery in the recipient. Previous surgery, such as a Kasai

hepatoportoenterostomy, obviously increases the risk of time-consuming adhesiolysis or hemorrhage. A misjudged estimation should undeniably create graft waiting time at the recipient site, yet this was not the case in our center, apparently because of correct estimation of the length of recipient hepatectomy. Of note, pre-transplant surgical procedures are indeed very often indicated in patients who will undergo pediatric LT, in particular in patients with biliary atresia who unquestionably can benefit from the Kasai operation. It is generally indicated to perform this very surgery, and our results should not be a consideration not to perform a hepatoportoenterostomy. However, the history of surgery must be considered in the estimation of the length of recipient hepatectomy since it significantly increases its duration.

The weight of the recipient significantly influenced graft waiting time at the recipient site in our center. For patients with a weight of more than 10 kg, the length of recipient hepatectomy was often *under*estimated. This might be explained by the inappropriate assumption of easier surgery in larger and older children.

Recovery of Other Organs After the Liver

Another important element influencing graft waiting time at the donor site, and thus indirectly increasing CIT, was the recovery of other organs after donor hepatectomy. The current practice in some places in Switzerland, unlike other European organ recovery structures, requires the surgeons recovering the liver to also procure other intra-abdominal organs, such as the kidneys and the pancreas. Yet, the kidneys are known to be less susceptible to CIT than the liver. Of note, the liver graft failure has been shown to increase for each additional hour of cold ischemia above 360 to 480 minutes [2-5], while a lower early graft survival is reported for the kidney above 1080 minutes [18], with a recommended CIT to be below 24 hours (1440 minutes) [19]. In this current study, we did not examine the CIT's influence on our recipients; a next step might be to complete our quality analysis with an analysis of the CIT's impact on the graft and recipient survival in our center. Even though it is certain that a change in practice would significantly save time in terms of CIT, an adjustment at the Swiss level, such as the recovery of the other organs by the receiving team or rather by the local donor site team, currently seems out of reach because of too important issues regarding human resources, their surgical training in organ recovery, and costs. Yet it is possible to suggest that donor surgeons thoroughly dissect the pancreas and the kidneys *before* the procurement of the liver and thus reduce its waiting time by shortening the procurement time of the following organs.

The efficiency of the coordination in our center in the past 10 years is satisfactory, with a mean CIT well under the 360 minutes threshold, above which the rate of complications is known to increase [2–12]. Likewise, the mean length of surgery in the recipient was below the intended maximal limit of 600 minutes [12–16]. However, some coordination issues were identified, creating waiting times and increasing CIT and length of surgery in the recipient, which must be addressed in the future, considering the above-described factors. One might argue that we didn't consider delays because of biopsies, which was an exclusion factor for our analysis. Yet donors for pediatric recipients have mostly excellent livers, and the need for biopsy is thus extraordinary, usually not predictable, and out of reach for improvement of the coordination process.

Limitations of this study are lying in some missing data, which yet were analyzed using reliable surrogate factors for its appraisal or with an expert's knowledge. Further, the length of the preparation on the back table was only estimated, and it was usually not documented; yet experience tells us that its duration is very stable. Analyses concerning the length of graft preparation on the back table are rare, except for brief descriptions in the case of specific reconstruction techniques [20] or comparison of in situ or ex situ methods in split graft LT [21]. Of note, *ex situ* splitting or graft reduction was an exclusion factor, with the idea of harmonizing the study cohort. Last but not least, besides CIT, other donor- and recipient-related factors play a major role in outcome after LT. However, this study explicitly and only aimed to determine factors during the logistic coordination of pediatric LT before implantation of the organ. These factors clearly influence CIT, one of the factors influencing the recipient's outcome. It was beyond the scope of this study to analyze all determining factors to be taken into consideration.

In conclusion, for the first time in the literature, this study allowed for highlighting of some crucial determinants to be taken into account during the logistic coordination of LT to optimize the coordination process and to avoid waiting times, in turn affecting CIT. It is of utmost importance that the recovery and recipient surgeons accurately estimate both donor and recipient hepatectomy time, and they must consider the variables potentially influencing the length of hepatectomy, such as graft type in donors, previous recipient surgery, as well as the recipient's weight.

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