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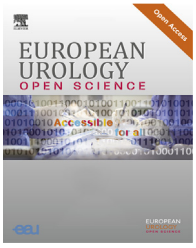

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Transperitoneal Versus Retroperitoneal Robotic-assisted Laparoscopic Pyeloplasty for Ureteropelvic Junction Obstruction in Children. A Multicentre, Prospective Study

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Abstract

Background: Robotic-assisted laparoscopic pyeloplasty (RALP) has been gaining acceptance among paediatric urologists.
Objective: To compare surgical variables and clinical outcomes, including complications and success rate, with RALP using the transperitoneal (T-RALP) and retroperitoneal (R-RALP) approaches.
Design, setting, and participants: We performed a multicentre, prospective, cohort study (NCT03274050) between November 2016 and October 2021 in three paediatric urology teaching centres (transperitoneal approach, n = 2; retroperitoneal approach, n = 1). The diagnosis of ureteropelvic junction obstruction (UPJO) was confirmed by renal ultrasound and mercaptoacetyltriglycine-3 renal scan or uro–magnetic resonance imaging with functional evaluation. The exclusion criteria were children <2 yr old, persistent UPJO after failed pyeloplasty, and horseshoe and ectopic kidney.
Intervention: We performed dismembered pyeloplasty using running monofilament 6-0 absorbable suture.
Outcome measurements and statistical analysis: We assessed intra- and postoperative morbidity (primary outcome) and success (secondary outcome). Data were expressed as medians and interquartile range (25th and 75th percentiles) for quantitative variables, and analysed comparatively.
Results and limitations: We operated on 106 children (T-RALP, n = 53; R-RALP, n = 53). Preoperative data were comparable between groups (median age 9.1 [6.2–11.2] yr; median weight 26.8 [21–40] kg). Set-up time (10 vs 31 min), anastomotic time (49 vs 73 min), and console time (97 vs 153 min) were significantly shorter

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with T-RALP than with R-RALP ($p < 0.001$). No intraoperative complications occurred. No conversion to open surgery was necessary. The median hospital stay was longer after T-RALP (2 d) than after R-RALP (1 d; $p < 0.001$). Overall, postoperative complication rates were similar. No failure had occurred at the mean follow-up of 25.4 (15.1–34.7) mo.

Conclusions: In selected children, RALP is safe and effective using either the transperitoneal or the retroperitoneal approach, with a shorter hospital stay after R-RALP.

Patient summary: In our multicentre, prospective study, we compared the results and complications of robotic-assisted laparoscopic pyeloplasty (RALP) using the transperitoneal and retroperitoneal approaches. We found that RALP is safe and effective using either approach, with a shorter hospital stay after R-RALP.

1. Introduction

Surgical management of ureteropelvic junction obstruction (UPJO) has dramatically evolved over the past 30 yr due to the development of new technologies. Laparoscopic pyeloplasty in children is a technically challenging procedure, requiring an experienced laparoscopist with a broad range of skills in advanced laparoscopy. It is associated with shorter hospitalisation and lower analgesic use than an open surgical approach [1]. The laparoscopic approach remains controversial due to a tedious learning curve and an operative time that is significantly longer than that for open pyeloplasty [2,3]. However, success rates and surgical outcomes are equivalent to those of the open procedure, including good functional outcomes [4–6].

In recent years, robotic-assisted laparoscopic pyeloplasty (RALP) has been gaining acceptance among paediatric urologists and is the most common robotic procedure performed in paediatrics [7]. Varda et al [8] evaluated the national trends of UPJO treatment modalities in children, and reported evidence of an increasing trend towards utilisation of RALP over laparoscopic or open pyeloplasty. The European Association of Urology paediatric guidelines acknowledged that "in good and experienced hands, the open, laparoscopic, or robotic approaches have the same good outcome" in pyeloplasty procedures [9].

However, there is still some controversy concerning which approach to choose for minimally invasive pyeloplasty: transperitoneal or retroperitoneal. In a preliminary study, we previously reported the feasibility and efficiency of retroperitoneal RALP (R-RALP) in children [10]. In the current study, we aimed to prospectively compare surgical variables and clinical outcomes, including complications and success, with RALP using either a transperitoneal (T-RALP) or a retroperitoneal (R-RALP) approach in three paediatric urology teaching centres.

2. Patients and methods

We performed a prospective cohort study in France between November 2016 and October 2021 in three centres: two for T-RALP (da Vinci Si Surgical System; Intuitive Surgical) and one for R-RALP (da Vinci Xi; Intuitive Surgical). The procedures were performed by one senior surgeon in each transperitoneal centre and by two senior surgeons and two fellows in the retroperitoneal centre.

The study received approval from an independent ethics committee (Comité de Protection des Personnes, CPP Ile de France VII). The sponsor was Assistance Publique—Hôpitaux de Paris (APHP, Clinical Research and Innovation Delegation), and the project was funded by a grant from Necker Hospital. It is registered with the ClinicalTrials.gov identifier NCT03274050.

Based on our strategy for UPJO obstruction, we excluded children younger than 2 yr old operated on by posterior lumbotomy or retroperitoneal laparoscopy, undergoing redo surgery for secondary UPJO, having horseshoe kidney, having ectopic kidney, or undergoing ureterocalicostomy [10]. The diagnosis of UPJO was confirmed by renal ultrasound and a technetium-99m mercaptoacetyltriglycine-3 (MAG-3) renal scan or uro–magnetic resonance imaging with functional evaluation. Indications for surgery in asymptomatic children were decreasing renal function on renal scan and/or increasing hydronephrosis on ultrasound. Patients with equal differential renal function (DRF) on the renal scan were symptomatic (ipsilateral flank pain and/or recurrent febrile urinary tract infections, and high blood pressure) with pyelocaliceal dilatation on ultrasound.

2.1. Surgical technique

For T-RALP, the straight-arm positioning technique as described by Chandrasoma et al [11] was used. As detailed previously, the surgical positioning and technique for R-RALP were standardised [10]. Three robotic ports and one accessory port were placed. In both approaches, the ureteropelvic anastomosis (Anderson-Hynes pyeloplasty) was performed with a 6/0 monofilament absorbable running suture using a 3/8-circle needle. After finishing the anterior line of anastomosis, we inserted either a one blind-ended or Magnetic Black-Star Urotech 4.7F polyurethane double-J stent through the assistant trocar positioned in an anterograde fashion, or an external pyelic stent. The external stent was connected to a drainage bag, clamped, and removed in the outpatient clinic after 12 d. If a double-J stent was used, it was planned to be removed after 4 wk. No perirenal drainage tube was systematically left in situ. Prophylactic antibiotics were administered by a single perioperative dose of ceftriaxone (50 mg/kg). In cases of aberrant polar vessels, the ureter was completely divided, and the ureteropelvic junction and pelvis were delivered anterior to the vessels with the help of the stay suture. The anastomosis was then performed as described. Each port site was infiltrated with a local anaesthetic.

Set-up time was counted from skin incision until the end of the port insertion. Console time was defined as the time taken to perform the procedure by the surgeon at the master console. Anastomosis time was the time needed to perform the anterior line of anastomosis, insert the double-J stent, and perform the posterior line of anastomosis.

The same protocols for postoperative care discharge pathways (analgesic requirements, oral food intake, and mobilisation) and pain control were used in the three centres: nalbuphine in the recovery room (0.2 mg/kg), and then regular acetaminophen 15 mg/kg up to q/6 h supplemented by nonsteroidal anti-inflammatory drugs as needed (ibuprofen 10 mg/kg). According to our protocol, children were discharged home after rehabilitation, when oral intake was tolerated, and postoperative pain was controlled with acetaminophen.

2.2. Complications and follow-up

Complications (primary outcome) were regarded as any deviation from the expected postoperative course according to the five-grade Clavien-Dindo classification [12]. Based on our protocol, follow-up consisted of a clinical visit associated with renal ultrasound at 1 mo after stent removal and then at 6 mo and 1, 2, and 5 yr [4]. A MAG-3 renal scan was performed in cases of significant asymmetric function in the preoperative study, or if follow-up showed no significant decrease of dilatation on ultrasound or persistence of symptoms [13].

Success (secondary outcome) was considered objectively as resolution of clinical symptoms, decrease in hydronephrosis on ultrasonography (anteroposterior diameter of renal pelvis and diameter of calices), and improvement of drainage on a MAG-3 renal scan without further impairment of renal function in patients who preoperatively had reduced DRF.

2.3. Statistical analysis

All statistical analyses were performed using R 4.0.3 software (http://cran.r-project.org). Data are expressed as medians and interquartile ranges (25th and 75th percentiles) for continuous variables, and as numbers and percentages for categorical variables.

Operative time was divided into two categories: <150 or ≥150 min for R-RALP, and <100 min or ≥100 min for T-RALP. Factors associated with console time were compared between these two groups using the chi-square test (or Fisher exact test, if appropriate) and the Student *t* test (or Wilcoxon test, if appropriate). All statistical tests were two sided, and *p* values below 0.05 were considered statistically significant.

3. Results

We operated on 106 children: T-RALP, *n* = 53; R-RALP, *n* = 53. Table 1 shows the demographics and indications for surgery. The preoperative data of both groups were comparable. The youngest child was 4.1 yr old in the T-RALP group and 2.1 yr old in the R-RALP group.

No intraoperative complications were encountered. All cases were completed using the robotic system, with no conversions to open surgery. The approach used had a significant impact on timing, resulting in a median set-up time, anastomosis time, and console time of 21, 24, and 56, respectively, shorter with T-RALP than with R-RALP ($p < 0.001$; Table 2). No factor was significantly associated with console time in the T-RALP group (Table 3). In the R-RALP group, the weight and presence of an aberrant crossing vessel were associated with a longer console time ($p = 0.04$ and $p = 0.03$, respectively; Table 3).

Table 1 – Demographics and indications for surgery

	T-RALP (*n* = 53)	R-RALP (*n* = 53)	*p* value
Age (yr)	9.2 (6.8–11)	8.0 (5.1–12.5)	0.42
Gender			0.84
Male	29 (55)	30 (57)	
Female	24 (45)	23 (43)	
Weight (kg)	26.5 (23–40)	27 (18–40)	0.42
Indication for surgery			0.70
Pain	34 (64)	31 (59)	
Prenatal hydronephrosis	8 (15)	10 (19)	
Postnatal hydronephrosis	7 (13)	5 (9)	
Urinary tract infection	4 (8)	5 (9)	
High blood pressure	–	2 (4)	
Side			0.69
Right	19 (36)	21 (40)	
Left	34 (64)	32 (60)	
Preoperative renal pelvis diameter	32 (25–38)	30 (27–39)	0.75
Preoperative imaging			
MAG3 renal scan	48 (91)	51 (96)	0.44
Magnetic resonance	11 (21)	13 (25)	0.64
Differential renal function <45%	21 (40)	27 (51)	0.47
Aberrant crossing vessel	28 (53)	20 (38)	0.12

MAG-3 = technetium-99m mercaptoacetyltriglycine-3; R-RALP = retroperitoneal robotic-assisted laparoscopic pyeloplasty; T-RALP = transperitoneal robotic-assisted laparoscopic pyeloplasty.
Values are expressed as the medians and interquartile range (25–75th percentiles), or n (%).

Table 2 – Surgical variables associated with the transperitoneal (T-RALP) or retroperitoneal (R-RALP) approach to robotic-assisted laparoscopic pyeloplasty

	T-RALP (*n* = 53)	R-RALP (*n* = 53)	*p* value *
Stent (%)			**<0.001**
One blind-ended JJ stent	53	58	
Black-Star magnetic stent	8	42	
External pyeloureteral stent	39	0	
Perirenal drainage	2 (4)	2 (4)	>0.99
Set-up time (min)	10 (10–14)	31 (28–40)	**<0.001**
Anastomosis time (min)	49 (42–57)	73 (66–91)	**<0.001**
Console time (min)	97 (87–122)	153 (135–185)	**<0.001**
Conversion, *n*	0	0	
Hospitalisation (d)	2 (1–2)	1 (1–1)	**<0.001**
Discharge on day 1	21 (40)	49 (92)	**<0.001**
Follow-up (mo)	24.6 (14.6–35.3)	25.6 (15.8–34.6)	0.65
Postoperative renal pelvis diameter	8 (6–14)	8 (5–11)	0.47
Complications (Clavien-Dindo)			0.32
I, II	9 (17)	9 (17)	
IIIa, IIIb	5 (9)	1 (2)	
Redo pyeloplasty, *n*	0	0	

Values are expressed as the medians and interquartile range (25–75th percentiles), or *n* (%).
* $p < 0.05$ (in bold) is considered statistically significant.

One-third of the procedures in the R-RALP group were performed by fellows with the assistance of one surgeon (T.B.). No pyeloplasty was performed alone by any of the fellows. There was no difference in terms of operative times and complications.

The median hospital stay was longer after T-RALP (2 d) than after R-RALP (1 d; $p < 0.001$). The external stent was removed in the outpatient clinic after a median of

Table 3 – Factors associated with console time using the transperitoneal (T-RALP) or retroperitoneal (R-RALP) approach to robotic-assisted laparoscopic pyeloplasty

Covariate	Console time		Univariate analysis*p* value *
	<100 min (*n* = 28)	>100 min (*n* = 25)	
T-RALP			
Age (yr)	9.1 (7.4–10.6)	9.2 (6.8–11)	0.95
Weight (kg)	26 (22–32)	30 (24–47)	0.24
Aberrant crossing vessel	15 (54)	13 (52)	0.91
Side			0.58
Right	11 (39)	8 (32)	
Left	17 (61)	17 (68)	
	Console time		
	<150 min (*n* = 24)	>150 min (*n* = 28)	
R-RALP			
Age (yr)	5.9 (4.3–11.1)	9.7 (6.3–13.5)	0.1
Weight (kg)	20 (16–35)	32 (23–45)	**0.04**
Aberrant crossing vessel	5 (21)	14 (50)	**0.03**
Side			0.48
Right	8 (33)	12 (43)	
Left	16 (67)	16 (57)	

Values are expressed as median and interquartile range (25–75th percentiles), or *n* (%).
* $p < 0.05$ (in bold) is considered statistically significant.

11 (11–13) d, while the double-J stent was removed after a median of 27 (17–35) d in the T-RALP group and after 36 (30–44) d in the R-RALP group ($p = 0.02$).

Ultrasound showed a decrease in hydronephrosis for all children (apart from three with residual hydronephrosis), with no difference between the two groups. Based on our protocol, we performed a postoperative MAG-3 renal scan in 22 children in the T-RALP group and 30 children in the R-RALP group. One child in the T-RALP group had a decrease in renal function (7%). In 23 children, the operated DRF improved (>3%).

Urinary tract infection (grade 2) was the most common postoperative complication in both the groups ($n = 15$; 14%), treated successfully with oral antibiotics except for two children whose double-J stent was removed. Overall, complication rates were similar, but Clavien-Dindo IIIb seemed more common in the T-RALP group (Table 4). At the mean follow-up of 25.4 (15.1–34.7) mo, no failures had occurred.

4. Discussion

Our multicentre series is the first to prospectively compare T-RALP and R-RALP in children. Both approaches achieved excellent results.

Table 4 – Postoperative complications requiring a new procedure (Clavien-Dindo grade III b)

Transperitoneal RALP (*N* = 5)
Loss of external pyelic stent, double-J stent insertion (day 1)
Double-J stent stuck at the ureterovesical junction, ureteroscopic repositioning
Urinary tract infection with anticipated double-J stent removal
Urinary tract infection with anticipated double-J stent removal
Double-J stent stuck at the ureterovesical junction, anastomotic leakage, repositioning of double-J stent (day 2)
Retroperitoneal RALP (*N* = 1)
Double-J stent stuck at the ureterovesical junction, ureteroscopic repositioning

RALP = robotic-assisted laparoscopic pyeloplasty.

Our rationale for performing the study was that there is still controversy concerning which approach to choose for minimally invasive pyeloplasty: transperitoneal or retroperitoneal. The transperitoneal approach enables a friendlier approach and a larger working space. The retroperitoneal approach allows direct access to the urinary tract, enabling conservative treatment in cases of anastomotic leakage because urine does not come into contact with the peritoneal cavity and organs [5,14,15]. It also minimises the risk of injury to intraperitoneal organs. Although there is a theoretical risk of intra-abdominal injury while performing a transperitoneal approach, it remains rare [14,16,17]. Interestingly, no such complication occurred in our series.

The transperitoneal approach is by far the most common approach for RALP in adults and children [1,18–20]. Olsen and Jørgensen [21] published the first series of R-RALP cases in 13 paediatric patients. The median operative time was 173 min, with no obstruction observed at follow-up, the median hospitalisation was 2 d, and only one complication occurred (ureteral stent occlusion). In 2007, Olsen et al [22] published an expanded series of 65 children with a follow-up of 5 yr. As highlighted by these authors, previous experience with retroperitoneal pyeloplasties using standard laparoscopic instruments facilitated transition to this new technology in our centres. Both the laparoscopic and the robotic approach share similar basic procedural and technical elements, with the same three instruments being used: monopolar scissors, bipolar forceps, and a needle holder. However, there are significant differences related to port placement and size.

A few papers have compared retroperitoneal and transperitoneal pyeloplasty in adults. The first prospective, randomised comparison in adults was published by Shoma et al [23] in 2007. Both approaches had satisfactory and comparable outcomes, without a significant difference in the success rate. The retroperitoneal approach was associated with a longer operative time (189 vs 149 min), but this was affected by the fact that the surgeon was at the start of the learning curve for retroperitoneal laparoscopic pyelo-

plasty. In 2010, Cestari et al [24] compared 36 cases of R-RALP and 19 cases of T-RALP. The operative time (137 and 139 min, respectively) and hospital stay (3.6 and 3.7 d, respectively) were similar, and the overall objective success rate was 96%, with two cases of failure (both in the retroperitoneal group) with a short follow-up. Ji et al [25] performed a systematic review to evaluate the clinical efficacy of laparoscopic pyeloplasty for UPJO via retroperitoneal and transperitoneal approaches. Twelve studies (only one in children) were identified, including a total of 777 patients (408 retroperitoneal). Both approaches had good success and low postoperative complication rates. They concluded that retroperitoneal laparoscopy requires more operative time than the transperitoneal approach, and that both approaches were similar in terms of postoperative hospital stay. In the only prospective, randomised trial in children, Badawy et al [15] compared transperitoneal and retroperitoneal laparoscopic pyeloplasties (19 in each group, aged 2 yr or older), performed by a surgeon with adequate and equal experience in both approaches. This is an important feature, as it alleviates any bias related to surgeon experience or learning curve. With the retroperitoneal approach, there was a shorter operative time (different from many other studies in the literature), a shorter hospital stay, rapid recovery of bowel movement, and earlier resumption of oral feeding than with the transperitoneal approach. However, it was not clear whether these differences were of clinical significance.

The three senior surgeons (T.B., O.A., and A.A.) had a large experience in laparoscopic pyeloplasty before starting robotic surgery. Yet even in experienced laparoscopic surgeons, robotic pyeloplasty required a specific learning curve. Our results showed a longer set-up time, anastomosis time, and console time with R-RALP. Although the longer set-up time can be explained by the additional time needed to create the retroperitoneal space, the difference in anastomosis time is more difficult to understand. In addition, since the retroperitoneal approach allows direct access to the urinary tract and easy detection of crossing vessels, the console time should not be longer with R-RALP. These findings may be explained by the fact that the two centres using the transperitoneal approach had already completed their learning curve, with 20 and 25 cases operated in each centre before the beginning of this study; in contrast, the retroperitoneal approach centre was at the start of their robotic programme and thus of their learning curve. Additionally, one-third of R-RALP surgeries were performed by fellows; this could also have influenced the differences concerning operating times. Shoma et al [23] indicated that the presence of a crossing vessel was significantly associated with increased operative times in the retroperitoneal approach. Concordant with their experience, we observed that the presence of crossing vessels significantly affected the operative time with R-RALP.

The most common complications observed in our study were related to the drainage (double-J stent and external pyelic stent), that is, malpositioning or displacement and urinary tract infection. In a meta-analysis, Liu et al [26] compared the double-J stent, external stented, and stentless procedures for paediatric pyeloplasty. Fifteen studies with 1731 participants were enrolled in the analysis, including four randomised controlled trials and 11 retrospective studies. The meta-analysis revealed no significant differences regarding operative times, operative success, hospital stay, improvement in renal function, overall complications, and redo pyeloplasty. The stent-less procedure showed advantages regarding flank pain and urinary tract infections.

One important finding in our study is the longer length of stay in the T-RALP group. The reduced hospital stay, with 49 children (92%) discharged on day 1 in the R-RALP group and 21 (40%) in the T-RALP group, will question the feasibility of performing robotic pyeloplasty in a same-day discharge setting. In a recent study, Neheman et al [27] presented their single-institution series of robotic reconstructive and extirpative paediatric urological procedures (n = 135), performed on an outpatient basis. The authors are the first to explore this concept in complex robotic procedures (including 62 pyeloplasties) and present the largest outpatient robotic surgery experience in paediatric urology to date.

Our study is associated with some limitations. Throughout the duration of the study, the da Vinci Si Surgical System was used for T-RALP, while the da Vinci Xi Surgical System was used for R-RALP. Each team was accustomed to its own system. However, we do not believe that this factor jeopardised the comparison of the outcomes, which would have been the case if one team had switched system during the study period. In addition, the comparison of three different centres with several surgeons of different levels of expertise will always entail a risk of different management pathways. Thus, before the beginning of the study, we established a common protocol within the three centres for postoperative care discharge pathways (analgesic requirements, oral food intake, and mobilisation) and for postoperative pain management. Furthermore, the study was performed in three university teaching hospitals and involved different surgeons (trainees and experienced surgeons); this did not impact the feasibility and safety of the procedures, but the difference in expertise between surgeons is clearly a limitation of the study. A major limitation of our study is that despite the prospective aspect, missing data led to the lack of evaluation of postoperative pain management and time to resume oral intake in the two groups. Badawy et al [15] found that analgesic requirement was not significantly different between the two groups. The fact that only children older than 2 yr were included in our study can also be regarded as a limitation. In 2020, Andolfi et al [19] published a review showing that the robotic transperitoneal approach to the UPJO enabled decreased operative times, a shorter length of hospital stay, and lower complication rates than, and success rates comparable with laparoscopic pyeloplasty—even in the more challenging cases, such as infants (defined as children $\leq$12 mo of age). Furthermore, a retrospective monocentric study [28] demonstrated that T-RALP in children <15 kg was feasible and effective to treat UPJO, with superimposable results to their heavier counterparts. In their experience, the need for a different trocar placement and limited space in patients <15 kg did not affect perioperative and functional outcomes. Andolfi et al

[29] from Chicago confirmed these results in 44 infants, with no conversions and no intraoperative complications. At a median follow-up of 19 mo, the success rate was 100%. For the retroperitoneal approach, as already stated [10], the larger robotic trocar diameter (8 vs 3 or 5 mm) limits its application to very small children. However, we feel that instrument size is not the limiting factor, as the procedure is performed in a restricted workspace with limited instrument movement, meaning a low risk of collision of the various parts of the robot. We consider that the major limitation lies more in the length/depth needed to operate the robotic instrument in the restricted area, that is, the retroperitoneal space in small children. In our study, the youngest child was 2 yr old and 12 kg in weight, older than the infants operated using laparoscopic pyeloplasty [30]. In the future, smaller instruments will hopefully be available, making the procedure more suitable for smaller children and infants, as with standard laparoscopic instruments.

5. Conclusions

RALP is safe and effective in selected children using either a transperitoneal or a retroperitoneal approach, with both achieving good outcomes. Regardless of the approach used, the most common postoperative complications were all stent related. Although the procedure is longer using the retroperitoneal approach, our analysis suggests an advantage for R-RALP in terms of a reduced hospital stay. A longer-term follow-up is awaited.

Author contributions: Thomas Blanc had full access to all the data in the study and takes responsibility for the integrity of the data and the accuracy of the data analysis.

Study concept and design: Blanc, Abbo, Arnaud.
Acquisition of data: Vatta, Grosman, Juricic, Laraqui, Broch.
Analysis and interpretation of data: Blanc, Abbo, Arnaud.
Drafting of the manuscript: Blanc.
Critical revision of the manuscript for important intellectual content: Arnaud.
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Data sharing: Data are not available to other researchers. The procedures carried out with the French data privacy authority (CNIL, Commission nationale de l'informatique et des libertés) do not provide for transmission of the database or the information and consent documents signed by the patients. Consultation by the editorial board or interested researchers may nevertheless be considered, subject to prior determination of the terms and conditions of such consultation and in respect for compliance with the applicable regulations.

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