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## Residual anastomoses in twin-twin transfusion syndrome after laser: the Solomon randomized trial

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**OBJECTIVE:** Residual anastomoses after fetoscopic laser surgery for twin-to-twin transfusion syndrome (TTTS) may lead to severe postoperative complications, including recurrent TTTS and twin anemia-polycythemia sequence (TAPS). A novel technique (Solomon technique) using laser coagulation of the entire vascular equator was recently investigated in a randomized controlled trial (Solomon trial) and compared with the Standard selective laser technique. The aim of this secondary analysis was to evaluate the occurrence and characteristics of residual anastomoses in placentas included in the Solomon trial.

**STUDY DESIGN:** International multicenter randomized controlled trial in TTTS, randomized 1:1 ratio to either the Solomon laser technique or Standard laser technique. At time of laser, surgeons recorded whether they considered the procedure to be complete. Placental dye injection

was performed after birth in the participating centers to evaluate the presence of residual anastomoses.

**RESULTS:** A total of 151 placentas were included in the study. The percentage of placentas with residual anastomoses in the Solomon group and Standard group was 19% (14/74) and 34% (26/77), respectively ( $P = .04$ ). The percentage of placentas with residual anastomoses in the subgroup of cases where the procedure was recorded as complete was 8/65 (12%) and 22/69 (32%) in the Solomon group and Standard group, respectively ( $P < .01$ ).

**CONCLUSION:** The Solomon laser technique reduces the risk of residual anastomoses. However, careful follow-up remains essential also after the Solomon technique, as complete dichorionization is not always achieved.

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### BACKGROUND AND OBJECTIVE

Twin-twin transfusion syndrome (TTTS), which occurs in 10% of monochorionic twins, is caused by imbalanced blood flow through placental vascular anastomoses. The best treatment, fetoscopic laser coagulation of the

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anastomoses, is associated with survival rates of both fetuses of 67%.

Although the goal of fetoscopic laser surgery is to coagulate all vascular anastomoses, intertwin vascular connections

remain patent in up to 33% of TTTS cases. Residual anastomoses can cause severe postoperative complications such as twin anemia-polycythemia sequence (TAPS) in 13-16% or recurrent TTTS in 7-14% of cases in which both babies survive.

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**TABLE**  
**Prevalence, number, and size of residual anastomoses**

Variable	Total			Laser complete (surgeon's opinion)		
	Solomon (n = 74)	Standard (n = 77)	P value	Solomon (n = 65)	Standard (n = 69)	P value
Placentas with residual anastomoses, n (%)	14 (19)	26 (34)	.04	8 (12)	22 (32)	< .01
Overall residual anastomoses per placenta, n <sup>a</sup>	2 (1–24)	2 (1–8)	.94	2 (1–4)	2 (1–5)	.90
Diameter of residual anastomoses, mm <sup>b</sup>	1.3 ± 1.8	0.8 ± 0.9	.07	2.1 ± 3.0	0.9 ± 1.0	.01
Placentas with arteriovenous residual anastomoses, n (%)	10 (71)	21 (91)	.11	6 (75)	17 (90)	.33
Placentas with arterioarterial residual anastomoses, n (%)	6 (43)	4 (17)	.09	3 (38)	2 (11)	.10
Placentas with venovenous residual anastomoses, n (%)	7 (50)	4 (17)	.04	4 (50)	3 (16)	.06

<sup>a</sup> Data are given as median (range); <sup>b</sup> Data are given as mean ± SD.

Slaghekke. Residual anastomoses in Solomon trial. *Am J Obstet Gynecol* 2014.

To minimize the occurrence of residual anastomoses and their complications, in a randomized controlled trial, we investigated a modified fetoscopic laser surgery technique. The aim of the Solomon technique is to draw a coagulation line along the entire vascular equator to reduce the risk of missing intertwin vascular anastomoses, especially poorly visualized small anastomoses.

In our previous analysis of the Solomon study, we focused on the perinatal outcome and showed a significant improvement in clinical outcome after the Solomon technique. The aim of this second analysis was to assess the placentas from the Solomon study and to determine the occurrence and characteristics of residual anastomoses. We also performed a subanalysis of all cases in which the surgeon reported that the procedure was technically complete.

## MATERIALS AND METHODS

The Solomon trial was an open-label randomized controlled trial that was performed in 5 European tertiary referral centers. Before injection, the placenta was washed with warm water, and amnions were removed for better visualization of the vascular anastomoses. The umbilical vein and at least 1 artery of

each cord were cannulated. Syringes with 4 colored dyes were connected to the cannulas, and dye was injected into the placental vessels. A measuring tape was placed on the placenta, and digital high-resolution pictures were taken perpendicular to the placental surface. The following placental characteristics were recorded: number, localization, size, and type of residual anastomoses.

The primary outcome of the Solomon trial was based on the short-term clinical outcome and included the presence of at least 1 of the following occurrences: TAPS, recurrent TTTS, perinatal death, and severe neonatal morbidity. A secondary outcome of the Solomon trial was the incidence of residual anastomoses. In this placental study, we analyzed the type, size, and localization of residual anastomoses after colored dye injection.

We compared the Solomon and standard groups among all injected placentas and in the subgroup of placentas from pregnancies in which fetoscopic laser surgery was recorded as complete, according to the surgeon's opinion directly after the laser intervention. This subgroup analysis was performed to determine the impact of the surgeon's opinion on the final result after fetoscopic laser surgery and whether this could be useful to direct postoperative management.

## RESULTS

A total of 247 placentas were eligible for this study. After 65 exclusions and 31 lost placentas, complete placental dye injection was performed in 151 placentas: 74 (49%) in the Solomon group and 77 (51%) in the standard group. The laser procedure was recorded by the surgeons as complete in 65 of 74 cases (88%) in the Solomon group and by 69 of 77 cases (90%) in the standard treatment group. There were no differences in baseline characteristics between the study groups with respect to gestational age at fetoscopy, placenta localization, or Quintero stage.

A significant reduction of residual anastomoses was seen after the use of the Solomon technique. Residual anastomoses were detected in 19% of the placentas (14/74) in the Solomon group vs 34% of the placentas (26/77) in the standard group ( $P = .04$ ). In the subgroup of cases in which laser surgery was recorded as complete by the surgeon, an even larger reduction of residual anastomoses was seen: 12% (8/65) in the Solomon group vs 32% (22/69) in the standard group ( $P < .01$ ; Table).

The risk for recurrent TTTS was 5% (4/77) in the standard group vs 1% (1/74) in the Solomon group ( $P = .19$ ). A significant reduction of TAPS of 22% (17/77) in the standard group to 4% (3/

74) in the Solomon group was seen ( $P < .01$ ). Overall, the incidence of TAPS and recurrent TTTS in cases with residual anastomoses was 48% (19/40) and 13% (5/40), respectively. The risk for TAPS in the group with residual anastomoses was 21% (3/14) in the Solomon group and 62% (16/26) in the standard group ( $P = .02$ ). The risk for recurrent TTTS in the group with residual anastomoses was 7% (1/14) in the Solomon group vs 15% (4/26) in the standard group ( $P = .64$ ). Residual anastomoses in TAPS cases were characterized by a smaller mean diameter  $0.4 \pm 0.5$  mm vs  $1.3 \pm 1.1$  mm in cases without TAPS ( $P < .01$ ).

#### COMMENT

In this second analysis of the Solomon trial, we showed that fetoscopic laser coagulation with the Solomon tech-

nique significantly reduces the incidence of residual anastomoses. This is the first randomized trial to show a reduction of residual anastomoses with a new laser technique in TTTS. Notably, however, even after the Solomon procedure, we found a clinically important number of residual anastomoses (19% in the overall Solomon group; 12% in the subgroup of placentas recorded as complete after the procedure). This highlights the fact that the Solomon procedure does not guarantee a complete dichorionization of the placenta. Therefore, careful follow-up examination with serial Doppler ultrasound measurements of middle cerebral artery peak systolic velocity and amniotic fluid volumes of both twins remains of crucial importance, even after a laser intervention with the Solomon technique.

#### CLINICAL IMPLICATIONS

- Fetoscopic laser coagulation for twin-twin transfusion syndrome with the Solomon technique reduced the risk for residual anastomoses.
- Reduction of residual anastomoses led to decreased risk for associated complications such as twin anemia-polycythemia sequence and recurrent twin-twin transfusion syndrome.
- Residual anastomoses in twin anemia-polycythemia sequence cases were characterized by a small diameter ( $<1$  mm).
- The risk for residual anastomoses after the Solomon technique persists; careful antenatal follow-up examination with Doppler ultrasound scanning remains necessary. ■

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