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Author: Slaghekke, Femke
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Chapter 4

Arterio-arterial vascular anastomoses in monochorionic twin placentas with and without twin anemia polycythemia sequence
Abstract

We performed a matched case-control study to analyze the placental angioarchitecture, in particular the diameter of arterio-arterial (AA) anastomoses in monochorionic placentas from pregnancies with spontaneous twin anemia-polycythemia sequence (TAPS) compared to a control group of uncomplicated monochorionic placentas. Placental angioarchitecture was analyzed using colored dye injection. AA anastomoses were detected in 20% (3/15) of spontaneous TAPS placentas. The median diameter of AA anastomoses in the group with and without TAPS was 0.4 mm and 2.2 mm, respectively (p = 0.01). In conclusion, AA anastomoses are rarely detected in TAPS placentas. When present, the AA anastomosis is very small, preventing equilibration of hemoglobin levels between both twins.
Introduction

Feto-fetal blood transfusion occurs in all monochorionic (MC) twins because of the invariable presence of placental vascular anastomoses and may lead to the development of twin anemia-polycythemia sequence (TAPS) [1]. TAPS is characterized by large inter-twin hemoglobin differences in the absence of amniotic fluid discordances [1]. The typical angi-architecture in TAPS placentas after colored dye injection demonstrates only a few minuscule arterio-venous (AV) anastomoses [2]. Arterio-arterial (AA) anastomoses are reported to be rare (10%) in TAPS [1]. In contrast, AA anastomoses are almost ubiquitous in normal monochorionic placentas [2], suggesting that AA anastomoses may play a protecting role against the development of TAPS [2].

We previously hypothesized that the diameter of AA anastomoses in TAPS may be smaller, preventing adequate inter-twin blood volume equilibration [3,4]. However, evidence to support this hypothesis is currently lacking. The objective of this study was to compare the diameter of AA anastomoses in MC twin placentas with and without TAPS.

Methods

All consecutive TAPS placentas examined at our center between June 2002 and November 2011 were included in this study. For the purpose of this study we excluded TAPS placentas without AA anastomoses. We also excluded TAPS cases that occurred after laser treatment for twin-twin transfusion syndrome (TTTS). Each spontaneous TAPS placenta was compared with 3 control placentas from uncomplicated MC twin pregnancies and matched for gestational age at birth (+/-1 week gestation). TAPS was diagnosed using standard antenatal ultrasound criteria and/or postnatal criteria [1].

Each MC placenta examined at our center is routinely injected with colored dye according to a previously described protocol [5]. After colored dye injection, placentas are photographed in a plain view, and digital pictures are saved for computer analysis. Data on placenta angiography, including the number and type of anastomoses, the percentage of placental territory and the type of umbilical cord insertion are prospectively entered in a dedicated database.

The primary outcome was the diameter of the AA anastomoses. Diameters of the AA anastomoses and individual placental territories were measured using Image Tool for 4
Results

A total of 491 MC placentas were injected during the study period, of which 44 (9%) fulfilled the diagnostic criteria for antenatal or postnatal TAPS. TAPS cases occurred after incomplete laser treatment for TTTS in 66% (29/44) of cases and occurred spontaneously in 34% (15/44) of cases. In this subgroup of 15 cases with spontaneous TAPS, an AA anastomosis was identified in 3 placentas (20%, 3/15). None of these TAPS cases were treated antenatally with fetoscopic laser coagulation. Each TAPS placenta (n = 3) was matched with 3 control MC placentas (n = 9). Mean gestational age at delivery was 32.3 weeks in both groups (range 29-36 weeks).

The median diameter of AA anastomoses in the group with and without TAPS was 0.4 mm (range: 0.3-0.6) and 2.2 mm (range: 0.7-3.5), respectively (p = 0.01). The diameter of the AA anastomosis was 1 mm in each TAPS placenta whereas only 2 AA anastomoses in the

<table>
<thead>
<tr>
<th></th>
<th>Study group (n=3)</th>
<th>Control group (n=9)</th>
<th>p value</th>
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</thead>
<tbody>
<tr>
<td>Number of anastomoses per placenta a</td>
<td>5 (3-6)</td>
<td>10 (3-16)</td>
<td>0.32</td>
</tr>
<tr>
<td>VV anastomoses present (%)</td>
<td>0 (0)</td>
<td>2 (22)</td>
<td>0.55</td>
</tr>
<tr>
<td>AV anastomoses present (%)</td>
<td>3 (100)</td>
<td>9 (100)</td>
<td>1.0</td>
</tr>
<tr>
<td>Diameter of AA anastomosis (mm) a</td>
<td>0.4 (0.3-0.6)</td>
<td>2.2 (0.7-3.5)</td>
<td>0.01</td>
</tr>
<tr>
<td>Placental share discordance (%) a</td>
<td>42 (24-64)</td>
<td>26 (11-43)</td>
<td>0.08</td>
</tr>
<tr>
<td>Unequal placental sharing&gt;20% - n(%)</td>
<td>3 (100)</td>
<td>2 (22)</td>
<td>0.11</td>
</tr>
<tr>
<td>Velamentous cord insertion - n(%) b</td>
<td>2/6 (33)</td>
<td>6/18 (33)</td>
<td>0.70</td>
</tr>
<tr>
<td>Marginal cord insertion - n(%) b</td>
<td>2/6 (33)</td>
<td>2/18 (11)</td>
<td>0.25</td>
</tr>
<tr>
<td>Velamentous or marginal cord insertion - n(%) b</td>
<td>4/6 (66)</td>
<td>8/18 (44)</td>
<td>0.32</td>
</tr>
</tbody>
</table>


a Value given as median (range).
b Refers to the type of cord insertion per fetus.

Table 1: Placental characteristics in the study group (TAPS placentas with an AA anastomosis) and control group (uncomplicated MC placentas with an AA anastomosis).
control group had a diameter 1 mm (22.2%, 2/9), leading to a sensitivity of 100% (3/3) and a specificity of 77.8% (7/9). A total of 11 AV anastomoses were detected in the 3 TAPS cases.

The direction of the AVs in the TAPS cases was mostly (64%, 7/11) from the anemic fetus to the polycythemic one. Further details on placental characteristics in both groups are shown in Table 1. An example of a TAPS placenta with a small AA anastomosis is shown in Fig. 1.

Discussion

This study shows that in the rare TAPS cases with an AA anastomosis, the diameter of the AA anastomosis is extremely small (≤1 mm), in accordance with our hypothesis [4]. In addition, this study confirms that only a minority of TAPS placentas (20%) contains an AA anastomosis [1], a significantly lower incidence compared to uncomplicated MC pregnancies (89%) [2]. Although the presence of an AA anastomosis may have an important protective effect, it does not preclude the development of TAPS [3,4,6].

![Figure 1. TAPS placenta after colored dye injection (blue and green for arteries, pink and orange for veins) with a small AA anastomosis (white star)(diameter of anastomosis: 0.3 mm). Detail of the AA anastomosis is shown in the bottom-right corner. The two green stars indicate two small AV anastomoses.](image-url)
The exact pathophysiologic role of the small AA anastomosis in the development of TAPS is not entirely clear. As previously shown, the pathogenesis of TAPS seems to be based on a unique angioarchitecture characterized by the presence of a paucity of minuscule vascular anastomoses [2]. The few small anastomoses allow a slow transfusion of blood (as low as 5-15 ml/24h) from the donor to the recipient, leading gradually to highly discordant hemoglobin levels [6,7].

AA anastomoses are bidirectional anastomoses and are thought to have protective properties against hemodynamic imbalance caused by AV anastomoses [8-10], as confirmed by a mathematical computer model [11]. However, the blood flow through a minuscule AA anastomosis is probably extremely low and insufficient to allow for adequate equilibration of the blood volumes between both twins. Inter-twin blood flow volume and velocity is known to be strongly correlated to the diameter of an anastomosis, according to Pouiseuille’s equation. Flow resistance depends linearly upon the viscosity and the length of a vessel, but depends to the fourth power upon the radius. Minuscule AA anastomoses may thus have a high flow resistance and thus fail to prevent the development of TAPS.

In conclusion, AA anastomoses in placentas with TAPS are rare. When present, the diameter of the AA anastomosis is small (≤1 mm), subsequently inhibiting adequate compensatory mechanisms and allowing development of TAPS. Disclosure All authors report no conflict of interest.
References


