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Ultrasound Obstet Gynecol 2025; **65**: 78–84
Published online in Wiley Online Library (wileyonlinelibrary.com). **DOI:** 10.1002/uog.29151

Critical procedural steps in intrauterine transfusion: Delphi survey of international experts

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KEYWORDS: Delphi survey; intraperitoneal transfusion; intrauterine transfusion; intravascular transfusion; IUT

ABSTRACT

Objective *To determine consensus, using Delphi methodology, on the critical procedural steps for intravascular intrauterine transfusion (IUT) for the treatment of fetal anemia.*

Methods *We conducted a two-part Delphi survey of international experts in fetal intervention. The first round of the survey proposed 32 potentially critical steps for the IUT procedure. Participants were asked to rate all steps on a Likert scale ranging from 1 (not important) to 5 (absolutely essential). We calculated the mean Likert score and 95% CI for all steps. Procedural steps were determined to be critical if the lower bound of the 95% CI was ≥ 3.0 and were excluded if the upper bound of the 95% CI was ≤ 3.5. In the second round of the survey, participants were asked specific questions regarding parameters associated with the procedural steps determined to be critical in the first round.*

Results *Overall, 49 individuals from 24 different countries (six continents) participated in both rounds of the Delphi survey. The median length of experience in fetal medicine was 21 (range, 4–38) years. The median number of IUT procedures performed annually per respondent was 20 (range, 2–80). Of the 32 proposed procedural steps, 20 were determined to be critical and 12 non-critical procedural steps were excluded. Respondents indicated that an individual should perform a median of 20 (range, 10–50) IUT procedures during training to attain competency, and that the median number of IUT procedures required annually to maintain competency was 10 (range, 5–20). There was marked variation between respondents in how they performed the following critical IUT procedural steps: preparation of donor blood, preoperative medication, maternal anesthesia, site chosen for cordocentesis, use of fetal paralysis, method for determining fetal hematocrit, postoperative care and decision to schedule a subsequent IUT.*

Conclusions *The findings of this international Delphi survey can be used to standardize the approach to performing IUT. An experienced fetal interventionist should perform the procedure, and in centers in which IUT is performed infrequently, referral to a more experienced center should be considered. Calculating the specific volume of blood to transfuse at the start of the procedure and undertaking continuous fetal heart-rate monitoring once the gestational-age threshold for viability is reached were ranked highest in the intra- and postoperative phases of the procedure, respectively.*

INTRODUCTION

Intrauterine transfusion (IUT) of donor red cells has been the accepted standard of care for the treatment of fetal anemia secondary to maternal red cell alloimmunization since it was first described by Liley[1] in 1963, who reported the introduction of packed red cells into the peritoneal cavity (intraperitoneal transfusion (IPT)) of three fetuses under fluoroscopic guidance. Injection of intra-amniotic and/or intraperitoneal radio-opaque dye for X-ray guidance helped to identify the appropriate location for needle insertion. Real-time ultrasound imaging later replaced

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Accepted: 6 November 2024

fluoroscopic guidance for the IPT procedures. In 1982, Bang *et al.*[2] were the first to report direct intravascular transfusion (IVT) using ultrasound guidance to access the intrahepatic umbilical vein. Descriptions of various methods for the procedure soon followed, including intracardiac transfusion, direct or exchange IVT using umbilical cord venous access and a combined IPT/IVT approach[3–7]. Fetal paralysis was later introduced, first as an intramuscular injection under ultrasound guidance and subsequently as part of the IVT procedure[8,9].

Lindenburg *et al.*[10] analyzed the performance of four operators at a Dutch national referral center and concluded that 34–49 procedures were required to attain competency in performing IUT, with 10 procedures needed annually to maintain competency. A recent international survey of 13 centers that perform IUT procedures found that only 15% of centers met this annual threshold[11]. Another survey noted that 60% of centers in the USA performed fewer than 10 IUT procedures annually[12]. Both surveys reported significant variation in practice for the preparation of blood products and for the IUT procedure itself.

Delphi methodology has been employed to establish best practice for fetal interventions, including shunt placement for lower urinary tract obstruction and laser therapy for early and late twin–twin transfusion syndrome[13,14]. Given the paucity of evidence regarding best practice for IUT, we employed a Delphi survey to determine the critical procedural steps for IUT during pregnancy.

METHODS

One of the authors (K.J.M.) developed a list of 32 potentially critical steps in the performance of IUT (Table S1), based on three decades of experience in performing these procedures. A survey tool was developed in a REDCap database and approved as exempt by the Institutional Review Board of Dell Medical School, The University of Texas at Austin, Austin, TX, USA (IRB STUDY00005525). Each proposed critical step was scored on a Likert scale of 1 (not important) to 5 (absolutely essential). A rating scale with 0.5 increments was used to allow for a gradation of response.

We then compiled a list of 77 international experts who routinely perform IUT, based on their participation in the DIONYSUS study[15], or who are known to be active in the field of fetal therapy. Invitations were limited to one expert per center. An invitation to participate in the survey was emailed to each of the 77 experts, including a unique link to complete the first round of the survey in REDCap. A reminder email to complete the survey was sent 2 and 4 weeks after the initial invitation.

The analysis of our results was based on methodology reported previously by investigators determining the critical procedural steps for performing laparoscopic colorectal surgery[16]. The mean Likert score with 95% CI was determined for each step. Procedural steps were determined to be critical if the lower bound of the 95% CI was ≥ 3.0 and were excluded if the upper bound of the 95% CI was ≤ 3.5. A procedural step was considered borderline if the lower bound of the 95% CI was < 3.0 and the upper bound was > 3.5. After the preliminary analysis of the results from the first round, the second round of the survey was sent to the participants, in which they were asked to reassess the borderline critical steps. Questions about specific parameters pertaining to the critical steps identified in the first round were also included in the second round of the survey (Table S2). Cronbach's alpha was calculated to determine internal consistency between respondents.

RESULTS

Of the 77 experts invited to participate in the Delphi survey, 49 (63.6%) responded to the first round. Respondents were from 24 different countries: 20 (40.8%) were from North America, 19 (38.8%) were from Europe, four (8.2%) were from South America, three (6.1%) were from Asia, two (4.1%) were from Oceania and one (2.0%) was from Africa. The mean ± SD age of the respondents was 54 ± 13 years. Overall, 69.4% of respondents were male and 30.6% were female. The median length of experience in fetal medicine was 21 (range, 4–38) years. The median number of IUT procedures performed annually per respondent was 20 (range, 2–80).

Of the 49 respondents, 30 (61.2%) responded to the initial invitation, 15 (30.6%) responded to the first reminder email and 4 (8.2%) responded to the second reminder email. In the first round of the survey, 20/32 (62.5%) steps were deemed critical (Table 1), 9/32 (28.1%) were deemed non-critical and 3/32 (9.4%) were considered borderline. Cronbach's alpha score was 0.91, indicating excellent reliability of the responses to the first round of the survey.

All 49 respondents participated in the second round of the survey. The three borderline procedural steps identified in the first round were ultimately deemed to be non-critical, therefore, a total of 12/32 (37.5%) steps were determined to be non-critical (Table 2). Thirteen additional questions were posed to qualify parameters pertaining to the procedural steps considered critically important (Table 3).

DISCUSSION

Several important concepts related to the performance of IUT during pregnancy were distilled by this international Delphi survey of experts in fetal medicine.

Experience level of operator

The critical step of having an experienced operator perform the procedure ranked second only to obtaining informed consent, with a mean Likert score of 4.79 in the present Delphi survey (Table 1). Participants indicated that a median of 20 (range, 10–50) procedures should be performed during a physician's training to achieve competency in performing IUT (Table 3). They also indicated that the median number of procedures required

Table 1 Steps deemed critical in first round of Delphi survey for performance of intrauterine transfusion (IUT)

Step	*Likert score Mean ± SD (95% CI)*
Preoperative phase	
Having an experienced fetal surgeon/interventionist perform the procedure	4.79 ± 0.40 (4.67–4.90)
Obtaining full informed consent from patient prior to procedure	4.91 ± 0.28 (4.83–4.99)
Using extended maternal red cell antigen crossmatch to select donor red cell unit for IUT	4.63 ± 0.63 (4.46–4.81)
Using CMV-negative donor blood for IUT	4.22 ± 1.15 (3.90–4.55)
Administering antenatal corticosteroids if gestational age has reached viability threshold	4.00 ± 1.09 (3.69–4.31)
Performing neonatology consultation prior to procedure if gestational age has reached viability threshold	3.52 ± 1.13 (3.20–3.84)
Intraoperative phase	
Warming donor red cell unit prior to infusion	3.82 ± 1.02 (3.53–4.11)
Using subcutaneous local anesthetic prior to needle insertion	3.60 ± 1.31 (3.23–3.97)
Administering fetal paralytic agent prior to IUT	3.68 ± 1.27 (3.33–4.04)
Accessing fetal umbilical vein for IVT of red cells	4.59 ± 0.52 (4.45–4.74)
Calculating specific volume of blood for IVT at start of procedure	4.65 ± 0.52 (4.51–4.80)
If performing IPT, injecting small volume of sterile saline to confirm proper needle placement prior to transfusion	3.47 ± 1.21 (3.13–3.81)
Having an automated blood analyzer available near the operating room at time of procedure to provide immediate results for fetal hematology	4.50 ± 0.73 (4.29–4.71)
Sending initial fetal sample for fetal blood antigen typing at patient's first IUT	3.93 ± 1.11 (3.61–4.24)
Monitoring cordocentesis site for bleeding via ultrasound after operative needle is removed	3.83 ± 1.04 (3.53–4.12)
Performing IPT only if unable to obtain fetal intravenous access	4.12 ± 0.73 (3.92–4.33)
Postoperative phase	
Continuous fetal heart-rate monitoring once gestational age has reached viability threshold	4.37 ± 0.87 (4.16–4.64)
Performing viability scan on postoperative day 1	3.41 ± 1.37 (3.05–3.83)
Performing subsequent IUTs at empiric intervals	3.70 ± 0.99 (3.49–4.04)
Performing final IUT at or around 35 weeks' gestation	3.71 ± 0.91 (3.42–3.97)

CMV, cytomegalovirus; IVT, intravenous transfusion; IPT, intraperitoneal transfusion.

Table 2 Steps deemed non-critical following second round of Delphi survey for performance of intrauterine transfusion

Step	*Likert score Mean ± SD (95% CI)*
Preoperative phase	
Administering a preoperative antibiotic for surgical prophylaxis	2.70 ± 1.44 (2.30–3.11)
Administering a preoperative tocolytic	2.58 ± 1.39 (2.19–2.97)
Administering a maternal preoperative anxiolytic	2.73 ± 1.08 (2.43–3.04)
Intraoperative phase	
Performing procedure in a sterile operating room	3.34 ± 1.42 (2.94–3.74)
Having a dedicated anesthesia provider present for procedure*	3.03 ± 1.46 (2.62–3.44)
Having patient's partner or a family member in procedure room	2.58 ± 1.01 (2.30–2.87)
Using maternal intravenous conscious sedation to perform procedure	2.53 ± 1.28 (2.17–2.89)
Administering a fetal analgesic agent prior to transfusion	2.11 ± 2.85 (2.11–2.85)
Performing IPT after intravascular transfusion in same setting	1.86 ± 2.33 (1.86–2.33)
Sending a final fetal sample for evaluation of fraction of fetal blood cells remaining compared with donor blood cells†	2.93 ± 1.10 (2.62–3.24)
Having fetal atropine available in operating room to administer into the umbilical vein in the event of fetal bradycardia	3.07 ± 1.21 (2.73–3.41)
Postoperative phase	
Discharging patient home on same day as procedure	3.19 ± 1.15 (2.89–3.52)

*Medical doctor, doctor of osteopathic medicine, certificated registered nurse anesthetist or anesthesiologist assistant. †Hemoglobin electrophoresis or Kleihauer–Betke stain. IPT, intraperitoneal transfusion.

annually for an individual to maintain competency is 10 (range, 5–20). These numbers are similar to those proposed by Lindenburg *et al.*[10] after studying the learning curve of four operators at a Dutch national referral center for fetal therapy. These authors used a cumulative sum statistical method to determine that a learning phase of 34–49 procedures was required to reach a level of competence that minimized procedure-related complications. In addition, they reported that the annual number of procedures required for an operator to maintain competency was 10. This number of procedures also preserves competency in the team assisting the operator. Three recent surveys of international fetal centers ($n = 13$), Canadian centers ($n = 9$) and centers in the USA ($n = 32$) found that 40%, 56% and 60% of centers, respectively, performed fewer than 10 IUT procedures per year[11,12,17]. These data speak to the need for standardization of the IUT procedure, especially in centers that perform the procedure infrequently. Alternatively, in centers in which IUT is performed infrequently, referral to a more experienced center could be considered to improve perinatal outcome.

Table 3 Responses to questions about parameters associated with critical steps in performance of intrauterine transfusion (IUT)

Parameter	*Response*
How many IUTs does a training physician need to perform to achieve competency?	20 (10–50)
How many IUTs does a physician need to perform annually to maintain competency?	10 (5–20)
If a donor unit is CMV-positive by serology but is leuko-reduced, would you use it for an IUT?	
No	40 (81.6)
Yes	9 (18.4)
Which agent do you use for subcutaneous local anesthesia prior to needle insertion for IUT?	
None	10 (20.4)
1% lidocaine	25 (51.0)
2% lidocaine	7 (14.3)
0.25% bupivacaine	5 (10.2)
0.5% bupivacaine	1 (2.0)
Other	1 (2.0)
Do you routinely use regional anesthesia for IUT?	
Never use regional anesthesia	36 (73.5)
Rarely use regional anesthesia	7 (14.3)
Epidural	5 (10.2)
Spinal	1 (2.0)
Which fetal paralytic agent do you use at the beginning of IUT?	
Intravascular route	20 (40.8)
Vecuronium	12/20 (60.0)
Rocuronium	8/20 (40.0)
Intramuscular route	11 (22.4)
Vecuronium	9/11 (81.8)
Rocuronium	2/11 (18.2)
None	12 (24.5)
Other	6 (12.2)
Which vessel do you typically target for intravascular transfusions (rank high to low)?	
UV at placental site > intrahepatic UV > free loop UV	22 (44.9)
UV at placental site > free loop UV > intrahepatic UV	16 (32.7)
Intrahepatic UV > UV at placental site > free loop UV	10 (20.4)
Intrahepatic UV > free loop UV > intrahepatic UV	1 (2.0)
How do you determine the volume of blood to transfuse during intravascular transfusion?	
Opening fetal hemoglobin or hematocrit	27 (55.1)
Weight-based calculation from estimated fetal weight	12 (24.5)
Other*	10 (20.4)
Which device(s) do you use at the time of IUT to evaluate fetal hematocrit or hemoglobin?†	
Point-of-care testing with HemoCue®‡	23 (46.9)
Automated hemocytometer located outside of operating area	9 (18.4)
Runner takes samples to central laboratory	9 (18.4)
Blood gas analyzer located near operating area‡	9 (18.4)
Point-of-care testing with I-Stat®‡	2 (4.1)
Point-of-care testing with spun capillary hematocrit‡	1 (2.0)
What methodology do you utilize to decide on when to perform subsequent IUTs?	
Calculated predicted decline in fetal hematologic indices	18 (36.7)
MCA-PSV Doppler	18 (36.7)
How often do you perform MCA-PSV Doppler? (weeks)	1 (1–2)
What value do you use as a threshold for performing the next IUT? (MoM)	1.55 (1.5–2.0)
Empiric intervals of time	8 (16.3)
Other§	5 (10.2)
For how long do you perform continuous fetal heart-rate monitoring after IUT? (h)	2 (1–12)

Data are given as median (range), *n* (%) or *n*/*N* (%). *See Table S3. †Respondents could select more than one option. ‡49.3% of point-of-care testing was reportedly confirmed by central laboratory (see Table S4). §See Table S5. CMV, cytomegalovirus; MoM, multiples of the median; MCA-PSV, middle cerebral artery peak systolic velocity; UV, umbilical vein.

Red cell preparation

A previous report indicated that several parameters are consistent across centers in the processing of red cells for IUT[18]. One such parameter is packing of the red cell unit to a higher hematocrit of > 75%, either through use of an automated cell washer or through manual centrifugation with removal of the supernatant. Using a higher hematocrit unit allows for the direct IVT of red cells without concern for fetal hypervolemia. Additionally, organizations in both the UK and the USA recommend using freshly donated units (< 7 days) that have been irradiated and are negative for hemoglobin S[19,20]. Irradiation is undertaken to prevent transfusion-associated graft-*vs*-host disease due to the immaturity of the fetal immune system. Seven cases of graft-*vs*-host disease

have been reported, although most have been associated with non-irradiated blood used in the setting of IUT or neonatal exchange transfusion[21]. One survey in the USA found that 63% of centers irradiated the cells within 6 h before use, but 16% performed the irradiation more than 24 h earlier[12]. Most guidelines recommend that this processing should take place less than 24 h prior to use to decrease the chance of hyperkalemia[22].

Our survey queried participants regarding two controversial areas of blood preparation for IUT. The first was the use of cytomegalovirus (CMV) seronegative donor blood. Our respondents considered this a critical step, with a mean Likert score of 4.22 (Table 1). In most centers, this procedural step involves screening the blood using serologic testing for CMV. Latent CMV resides in monocytes. The use of leukocyte-poor filters by many centers in the preparation of the red cell units for IUT should prevent transmission of the virus, even if serologic testing is positive. When participants were queried in the second round of our Delphi survey, 82% stated that they would not use a CMV seropositive red cell unit even if it was leuko-reduced (Table 3). In the case of multiple maternal red cell antibodies, a leuko-reduced but CMV seropositive red cell unit may be the only unit available. In support of using the unit, a recent meta-analysis of two studies that compared adding CMV testing to leukoreduction with leukoreduction alone found no significant difference in the rate of clinical or laboratory CMV infection[23].

A second area of controversy concerns using an extended maternal crossmatch when selecting the red cell unit for IUT. The present survey deemed extended maternal cross-matching as a critical step, with a mean Likert score of 4.63 (Table 1). This result is inconsistent with surveys conducted in the USA and Canada[12,20]: the former found that 76% of red cell units used for IUT were crossmatched only to the offending maternal antibody, while in the latter, extended crossmatching was practiced in only one of nine centers. We believe that this discrepancy is related to the poor wording of the proposed procedural step. The question was meant to ascertain whether centers undertook extended maternal phenotyping before selecting a unit of red cells for IUT. Schonewille *et al.*[24] investigated using extended maternal phenotyping for Duffy, Kidd and S antigens to select red cell units for IUT on the basis that this could prevent the formation of new red cell antibodies beyond the initial alloimmunization. When extended crossmatching was used, alloimmunization to these additional antigens decreased by 60% compared with when units were crossmatched to only the existing maternal antibodies. This finding led one group to suggest that an extended crossmatch for additional maternal red cell antigens should be undertaken when selecting a red cell unit for IUT[18]. In the future, this may be undertaken more readily through universal blood donor genotyping[25].

Finally, warming the blood used for IUT prior to infusion was determined to be a critical step in this survey (mean Likert score, 3.82) (Table 1). This is consistent with British Society for Haematology guidelines, which recommend warming blood products due to the potential for fetal bradycardia if the blood is infused at its stored temperature of 4°C[20]. These guidelines suggest that sunlight or a radiant warmer should not be used because they may increase the chance of hemolysis. Further research is needed to identify and/or develop warming systems specifically designed for the small volume of blood required for IUT.

Preoperative preparation

Using preoperative tocolytics or antibiotics was not determined to be a critical step in the present Delphi survey (mean Likert scores of 2.58 and 2.70, respectively) (Table 2). However, administering antenatal steroids and conducting a neonatology consultation once the gestational-age threshold for viability is surpassed were considered critical steps (mean Likert scores of 4.00 and 3.52, respectively) (Table 1).

Maternal anesthesia

Use of intravenous sedative or anxiolytic medications was not determined to be a critical step for IUT in this survey (mean Likert scores of 2.53 and 2.73, respectively) (Table 2). However, injecting local anesthesia prior to needle insertion was determined to be critical, with a mean Likert score of 3.60 (Table 1). Sixty-five percent of respondents used lidocaine for injection (Table 3). Seventy-four percent of respondents stated that they never used regional anesthesia; among those who did, the majority utilized an epidural.

Site of cordocentesis

In this Delphi survey, 45% of centers used the umbilical vein at the cord insertion site (UVC) as the primary target, with the intrahepatic umbilical vein (IHV) as the secondary target, 33% of centers used the UVC as the primary target followed by a floating loop of cord as the secondary target, and 22% of centers used the IHV as the primary target (Table 3). Many European centers use the IHV as their primary target, while North American centers tend to use the UVC. Somerset *et al.*[26] audited their institutional IUT experience and noted no significant difference in outcomes between use of the UVC *vs* IHV. In one large series, cordocentesis into a floating loop of cord was associated with a two-fold increase in procedure-related complications (odds ratio (OR), 2.1 (95% CI, 1.0–4.5))[27]. This might indicate that the IHV is a better target when the umbilical vein is not accessible at the cord insertion site.

Initial fetal hematologic assessment

Immediate assessment of fetal hemoglobin and determination of fetal antigen status at initial cordocentesis were considered critical steps (mean Likert scores of 4.50 and 3.93, respectively) (Table 1). When further queried as to the method of hematologic assessment, 47% of respondents reported using the HemoCue® (Ängelholm,

Sweden) device, 18% used an automated hemocytometer located outside of the operating area, 18% used a runner to take the sample to a central laboratory, 18% used a blood gas analyzer, 2% used a spun hematocrit and 4% used an I-Stat® (Abbott, Chicago, IL, USA) device (Table 3). Furthermore, 49% of centers that used point-of-care devices also sent a sample to a central laboratory for confirmation. Delabaere *et al.*[28] compared readings from 244 paired samples analyzed with the HemoCue device and a XN10® (Sysmex, Kobe, Japan) automated hemocytometer and noted a concordance coefficient of 0.979. Thus, if an automated hemocytometer is not immediately available, assessment with a HemoCue device followed by central laboratory confirmation might be the optimal method for determining the fetal hematologic status at the time of the procedure.

Fetal paralysis

Routine use of fetal paralysis is adopted at many IUT centers. In our Delphi survey, it was deemed a critical step, with a mean Likert score of 3.68 (Table 1). This is supported by the findings of a large series of 1678 IUT procedures in which fetal paralysis was associated with an 80% reduction in procedure-related complications (OR, 0.2 (95% CI, 0.1–0.5))[27]. Moreover, 41% of respondents to our survey reported administering a paralytic agent at the time of intravascular access (Table 3). The most commonly used intravascular paralytic agent was vecuronium (60%). Moreover, 22% of centers administered a paralytic agent intramuscularly, of which 82% reported using vecuronium for this route.

Postoperative monitoring

Discharging the patient home on the same day as the procedure was ranked as a non-critical step in the IUT procedure (mean Likert score, 3.19) (Table 2). Most centers reported that undertaking fetal heart-rate monitoring after the IUT procedure once the gestational-age threshold for viability has been reached was important (mean Likert score, 4.37) (Table 1). The median duration of postoperative monitoring reported by respondents was 2 (range, 1–12) h (Table 3). Performing a viability ultrasound scan the day after the procedure was also considered a critical step among our respondents (mean Likert score, 3.41).

Timing of subsequent IUT

Using empiric intervals to determine when to perform subsequent IUTs received a mean Likert score of 3.70 among the respondents to our Delphi survey and qualified as a critical step (Table 1). On further inquiry during the second round, 37% of centers reported using serial measurements of fetal middle cerebral artery peak systolic velocity (MCA-PSV) to determine the timing of subsequent IUT and 37% based their decision on the expected decline in fetal hemoglobin (Table 3). Among the respondents who reported using MCA-PSV, the median scan frequency was once weekly and the median threshold value was 1.55 multiples of the median (MoM).

In a randomized controlled trial of 71 patients, Dodd *et al.*[29] compared use of a MCA-PSV threshold of 1.5 MoM *vs* an anticipated decline in fetal hemoglobin of 0.3 g/dL/day for determination of the timing of subsequent IUT. No differences were found in the number of IUT procedures performed. However, it was noted that in the MCA-PSV group, neonatal hemoglobin values were lower at delivery and there was a greater need for neonatal exchange transfusion. Center preference plays a dominant role in which method is used to determine when subsequent IUTs are performed, although an empiric interval approach might be more cost-effective.

Of note, performing the last IUT at 35 weeks' gestation was considered a critical step (mean Likert score, 3.71) by the respondents to our survey (Table 1). This supports the decision to continue IUTs until this gestational age threshold is met, with anticipated delivery several weeks later. This approach would theoretically allow for the development of hepatic maturity and decrease the need for neonatal exchange transfusion[30].

Strengths and limitations

Our survey received responses from 49 experts from 24 different countries, a number that is considered optimal for most Delphi studies[31]. Of the centers included, 82% met the threshold of 10 annual IUT procedures that was proposed previously in the literature for the maintenance of competency[10]. This suggests that our study includes a representative sample of centers with considerable experience of performing IUT procedures.

Much like any Delphi survey, the steps of the IUT procedure that were determined to be critical were not based on evidence from clinical trials, but rather expert opinion and local patterns of practice. Participants may have misinterpreted some queries, as was discussed in relation to extended crossmatching of the donor unit.

Conclusions

This international Delphi survey provides valuable information for the standardization of clinical practice in performing IUT. Having an experienced fetal interventionist perform the procedure ranked only second to obtaining informed consent in the preoperative phase. Calculating the specific volume of blood to transfuse at the start of the procedure and undertaking continuous fetal heart-rate monitoring once gestational age has surpassed the viability threshold were ranked highest in the intra- and postoperative phases, respectively.

ACKNOWLEDGMENT

The following experts comprised the Delphi IUT Study Group: E. Antolin, F. Audibert, A. A. Baschat, M. Bebbington, J. A. Benavides-Serralde, A. Borrell, R. Chmait, V. Debarge, R. Devlieger, R. Donepudi,

E. Ellis, S. P. Emery, L. Geerts, A. Geipel, J. Gibson, K. P. Gloning, J. M. Gonzalez Velez, W. Goodnight, K. Hecher, J. M. Jouannic, M. Kilby, K. Kirill, P. Klaritsch, M. Lanna, F. Maia Peixoto-Filho, F. Malone, K. B. Markham, R. J. Martinez Portilla, C. H. Meller, R. Miller, H. Mustafa, P. Pandya, L. Pereira, T. Premru-Srsen, A. E. Rodrigues Baião, T. Sarac Sivrikoz, W. Sepulveda, A. A. Shamshirsaz, C. Sheppard, B. Silver, J. Smoleniec, S. Snowise, V. Stefanovic, E. Tiblad, M. Treadwell, T. Trevett, E. J. T. Verweij, R. Windrim and Y. Yinon.

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SUPPORTING INFORMATION ON THE INTERNET

The following supporting information may be found in the online version of this article:

Table S1 Questions in first round of Delphi survey

Table S2 Questions in second round of Delphi survey

Table S3 'Other' responses to the question: How do you determine volume of blood to transfuse during intravascular transfusion?

Table S4 All responses to the question: Which device(s) do you use at the time of intrauterine transfusion to evaluate fetal hematocrit or hemoglobin?

Table S5 'Other' responses to the question: What methodology do you utilize to schedule subsequent intrauterine transfusions?

