AIUM/QIBA
Ultrasound Volume Blood Flow Biomarker

Call Summary 06-July-2020

Attendees: Oliver Kripfgans, Jing Gao, Brian Fowlkes, Cy Lee, Tim Hall, Stephen Pinter, Cristel Baiu, Todd Eperdling, Jim Jago, Kang Yu, Jon Rubin, Sriram, Andy Miklowski, Paul Carson

Action Items in red

1) Review of Previous Call Summary - Approved
   a) Previous Action Items
      i) Vendor survey of 2D spectral Doppler methods for volume flow. So far only one response despite multiple requests.
      ii) Jim Jago will be sending Therese a new survey question as well as answers to a few of the questions not answered.

2) Update on *Radiology* Publication of Round Robin Groundwork
   a) Update on Manuscript (*3D Ultrasound Enables Accurate, Noninvasive Measurements of Blood Flow*)– accepted and selected for a press release
      i) Brian asked Tim if press releases are common these news releases a common thing? Tim stated that it's only happened a couple of times.
      ii) The contribution from everyone is greatly appreciated.

3) Update on VBF Profile Discussions
   a) 3 areas covered
      i) Blood Supply to the Umbilical Cord
         (1) Question: For the human umbilical cord are there only three vessels? For human that is the case. Other species can have a much more complicated vascular structure in the cord most likely due to the number of gestations or the size.
         (2) The consequence of this answer is that you should be getting the same volumetric flow along the entire length of the cord.
      ii) Portal venous flow
         (1) Background: In a previous discussion in the profile task group it was suggested that there might be a standard fudge factor used modified the standard Doppler mean estimate velocity and cross sectional based on diameter. Therefore, tasked with doing a literature search. Jon R. did not find a fudge factor. What was found.
            (a) Discussed 2 interesting and relevant papers

(i) "Measurement of normal portal venous blood flow by Doppler ultrasound" by Brown et al. Gut, 30,503-509, 1989.
1. Used ellipse approximation. Transverse image. Results routinely overestimated the volume flow. Almost always biased high; larger the cross section, the higher the bias. The error is really high in terms of measuring cross sections and they did measure diameter. They basically came up with a fudge factor and based on the regression line and varied depending of the diameter and area of the vessel. None of the estimates were great. Overall random error was 20% error.

(ii) Discussed the paper, "Portal Vein blood flow measurement using pulse Doppler and Electromagnetic Flowmetry in Dogs: A Comparative Study" by Dauzat and Layrargues, Gastroenterology, 96,913-919, 1989.
1. Means were approximately the same, the variation was twice as high. 11% versus 6% comparing flow meter. Bottom line was that they compared the mean estimate to the estimated peak value. They got variation and not always was the mean velocity one half of the peak, i.e. not parabolic flow. Potential problem using this technique in measuring VF.

(b) The recommendation would be to use the mean making sure the beam sampling across the vessel is sufficient to either encompass the velocity present or the beam profile across the vessel is sufficiently narrow so that you can make some assumptions about circular symmetry.

iii) 2D Spectral Doppler Method

(1) Update on umbilical venous volume flow –

(a) Reviewed paper by Boito came up because it very clearly is looking at using mean velocity for making a measurement of the volumetric flow and then using an ellipsoid to measurement of the area. See slide for more information. Slide with figures: the open circles are the normal size fetus and closed circles are the small for gestational age.

(b) Other reference paper by Vimpeli. See slide. Waveform and diameter of the umbilical vein were measured at the intra-abdominal straight portion of the vessel. Repeatability of VBF measurements (see table 1)

4) Matters Arising

a) Profile Working Group –

i) Dividing into 3 areas. Clinical Rationale and Performance, Quality Assurance and Phantoms and Image Acquisition and Analysis

ii) Recommended to distribute the efforts.

b) We will be extending the QIBA calls in August and September

c) Ask Jim Zagebski to be involved in the QA and phantoms component.

d) Members are welcome to join the VF profile calls 2nd Wednesday and 4th Wednesday of each month. Contact Therese or Brian if you would like to join.

QIBA VBF Discussion

06-July-2020

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Agenda

- Review of Previous Call Summary
  - Action Items
    - Vendor survey of 2D spectral Doppler methods for volume flow
- Update on *Radiology* Publication of Round Robin Groundwork
- Update on VBF Profile Discussions
- Matters Arising

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Previous Action Items

- Vendor survey of 2D spectral Doppler methods for volume flow
- So far only one response despite multiple requests.
- Please consider responding!

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Survey

Vendor Survey regarding Volume Flow

Please complete this survey in order for the QIBA Volume Flow Biomarker Committee to acquire more information for the Profile activities.

- Name
  First Last
- Email
- What manufacturer do you represent?
- What method does your system use for volume flow measurement?
  - It is based on maximum velocity
  - It is based on mean velocity
- Is there a published reference that describes your method?
- How does your system direct the user to obtain Doppler angle?

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Survey

- Angle corrected by the operator
- User directed to orient the vessel to minimize Doppler angle.
- Both depending on application

- What is the equation associated with the calculation of volume flow?
- Is any aspect of the the Doppler method user selectable?
  Yes
- Is it selected based on application
  Yes
- Please explain the rationale/technical justification for the selections?
- Can you supply the description of the procedure for volume flow from your user manual?
- What is your quoted measurement accuracy?

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Survey

- What is your test procedures to validate the volume flow tools?

6

*** What method does your system use for volume flow measurement?**

It is based on mean velocity

*** Is there a published reference that describes your method?**

Evans, D. H., McDicken, W. N. Doppler Ultrasound, Physics, Instrumentation, and Signal Processing. Second Edition. John Wiley & Sons, Ltd, 2000.

*** How does your system direct the user to obtain Doppler angle?**

Angle corrected by the operator

*** What is the equation associated with the calculation of volume flow?**

Page 288 from the reference. VFlow (cc/min) = Area(cm^2)* abs(TAMV (cm/s)) * 60 (s/in)

*** Is any aspect of the the Doppler method user selectable?**

No

*** Is it selected based on application**

No

*** Please explain the rationale/technical justification for the selections?**

Couldn't access the information from Home

*** Can you supply the description of the procedure for volume flow from your user manual?**

Couldn't access the information from Home

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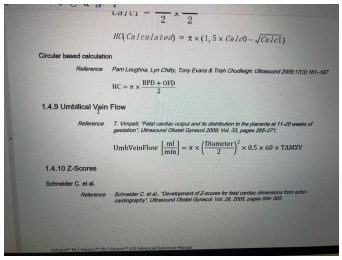
Voluson Umbilical Venous Blood Flow



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Radiology Publication

RSNA Radiological Society of North America

RADIOLOGICAL SOCIETY OF NORTH AMERICA
820 JORIE BLVD, OAK BROOK, IL 60523
TEL 1-630-571-2670 FAX 1-630-571-7837
RSNA.ORG

NEWS

Contact: RSNA Media Relations: 1-630-590-7762

Linda Brooks — 1-630-590-7738 — lbrooks@rsna.org
Dionna Arnold — 1-630-590-7791 — darnold@rsna.org

Embargoed for release on June 30, 2020, at 10:00 a.m. ET

3D Ultrasound Enables Accurate, Noninvasive Measurements of Blood Flow

AT A GLANCE

- **3D ultrasound provides an effective, noninvasive way to estimate blood flow.**
- **Measurements of blood flow are important in cases of chronic illnesses and emergency situations.**
- **The research was the work of Quantitative Imaging Biomarkers Alliance (QIBA).**

OAK BROOK, Ill. — A 3D ultrasound system provides an effective, noninvasive way to estimate blood flow that retains its accuracy across different equipment, operators and facilities, according to a study published in the journal *Radiology*.

Measures of blood flow are important in helping clinicians determine how much oxygen and nutrient-carrying blood is reaching organs and tissues in a patient's body. In emergency situations, accurate blood flow measurements can show if there is adequate blood supply to organs like the heart and brain. Blood flow measurements are important in chronic conditions too, as in the cases of measuring blood flow to the feet and lower limbs of people with diabetes.

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Profile Discussions

- Blood Supply to the Umbilical Cord
- Portal venous flow
- 2D Spectral Doppler Method

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STEM CELLS TRANSLATIONAL MEDICINE

TISSUE-SPECIFIC PROGENITOR AND STEM CELLS

Concise Review: Wharton's Jelly: The Rich, but Enigmatic, Source of Mesenchymal Stromal Cells

JOHN E. DAVIES,[a,b] JOHN T. WALKER,[c] ARMAND KEATING[a,d]

Key Words. Wharton's Jelly • Mesenchymal stromal cell • Embryology • Therapy

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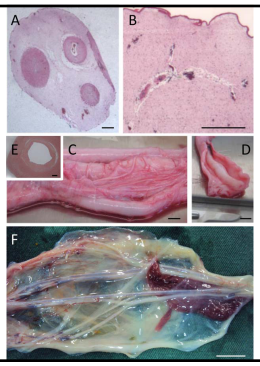

Figure 4. Comparative anatomy of the umbilical cord. **(A, B)** Porcine, **(C-E)** Equine, **(F)** Canine. (A): Unlike the human cord, the perivascular zones are not clearly demarcated in the porcine cord. (B): In the porcine cord, Wharton's jelly contains many small vascular structures. (C): The equine cord has four major vessels and many co-lateral and branching vessels. (D): Each of the main vessels has a well-developed tunica adventitia as seen in this dissected specimen. (E): The tunica adventitia is distinct from the tunica media in this H&E stained cross-section. (F): Like the equine cord, the canine cord has multiple vessels with co-lateral branching. The vessels are contained within the amniotic epithelium but, unlike the human, porcine and equine cords, does not from a firm roughly circular but rather a diffuse and flattened structure. [Image courtesy of Dr. Emily Correna Carlo Reis]. Scale Bars: A, B and E = 1 mm; C, D and F = 1 cm.

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Portal Venous Flow

Gut, 1989, **30**, 503–509

Liver, biliary, and pancreas

Measurement of normal portal venous blood flow by Doppler ultrasound

H S BROWN, M HALLIWELL, M QAMAR, A E READ, J M EVANS, AND P N T WELLS

From the Department of Medical Physics, Bristol and Weston Health Authority, and the Department of Medicine, University of Bristol, Bristol

SUMMARY **The volume flow rate of blood in the portal vein was measured using a duplex ultrasound system. The many errors inherent in the duplex method were assessed with particular reference to the portal vein and appropriate correction factors were obtained by *in vitro* calibration. The effect of posture on flow was investigated by examining 45 healthy volunteers in three different positions; standing, supine and tilted head down at 20° from the horizontal. The mean volume blood flow in the supine position was 864 (188)ml/min (mean 1SD). When standing, the mean volume blood flow was significantly reduced by 26% to 662 (169)ml/min. There was, however, no significant difference between flow when supine and when tilted head down at 20° from the horizontal.**

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Portal Venous Flow

GASTROENTEROLOGY 1989;96:913–9

Portal Vein Blood Flow Measurements Using Pulsed Doppler and Electromagnetic Flowmetry in Dogs: A Comparative Study

MICHEL DAUZAT and GILLES POMIER LAYRARGUES

Liver Unit, Department of Medicine and André-Viallet Clinical Research Center, Hôpital Saint-Luc and Université de Montréal, Montreal, Quebec, Canada; and Vascular Unit, Centre Hospitalier Regional and Université de Nîmes, Nîmes, France

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Ultrasound Obstet Gynecol 2002; 19: 344–349

Umbilical venous volume flow in the normally developing and growth-restricted human fetus

S. BOITO*‡, P. C. STRUIJK*, N. T. C. URSEM*, Th. STIJNEN† and J. W. WLADIMIROFF*

*Departments of *Obstetrics and Gynaecology, and †Epidemiology and Biostatistics, Erasmus University Medical Centre, University Hospital Rotterdam-Dijkzigt, Rotterdam, The Netherlands and ‡Department of Maternal and Child Health, Biology and Genetics, University of Verona, Verona, Italy*

KEYWORDS: Flow velocity, Volume flow, Umbilical venous vessel size

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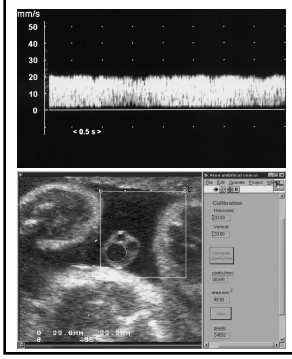

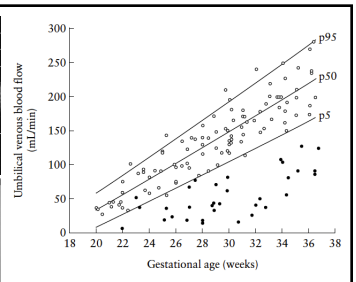

Figure 5 Umbilical venous volume flow (mL/min) relative to gestational age (GA). Open circles (○), individual normal values; solid line (—), 5th (p5), 50th (p50) and 95th (p95) centile reference lines; closed circles (●), SGA fetuses. p50: cubic fit = $0.000328 \times GA^3 + 10.944931 \times GA - 188.288068$. p5–95: $p50 \pm 1.64(0.928218 \times GA - 6.422451)$.

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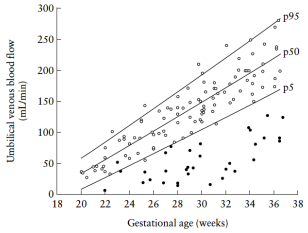

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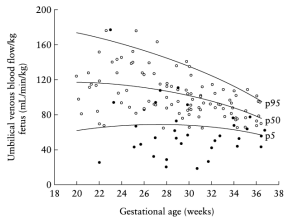

Figure 6 Umbilical venous volume flow/kg estimated fetal weight (mL/min/kg) relative to gestational age (GA). Open circles (○), individual normal values; solid lines (—), 5th (p5), 50th (p50) and 95th (p95) centile reference lines; closed circles (●), SGA fetuses. p50: cubic fit = $-0.001670\ GA^3 + 1.579665 \times GA + 99.293341$. p5–P95: $p50 \pm 1.64(-1.076244 \times GA + 48.623154)$.

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Voluson Umbilical Venous Blood Flow

Ultrasound Obstet Gynecol 2009; **33**: 265–271
Published online 30 October 2008 in Wiley InterScience (www.interscience.wiley.com). **DOI:** 10.1002/uog.6247

Fetal cardiac output and its distribution to the placenta at 11–20 weeks of gestation

T. VIMPELI*, H. HUHTALA†, T. WILSGAARD‡ and G. ACHARYA§

**Central Maternity Unit, City of Tampere and †Tampere School of Public Health, University of Tampere, Tampere, Finland and ‡Institute of Community Medicine, University of Tromsø and §Department of Obstetrics and Gynecology, Institute of Clinical Medicine, University of Tromsø and University Hospital of Northern Norway, Tromsø, Norway*

KEYWORDS: blood flow; cardiac output; Doppler; fetal heart; placenta

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Vimpeli et al. 2009

- For umbilical venous flow
  - Waveform and diameter of the umbilical vein were measured at the intra-abdominal straight portion of the vessel.
  - The blood flow velocity waveform was recorded for 2–4 s and TAMXV was measured.
  - Assumes a parabolic velocity profile and circular cross-section of the vessel
  - References Acharya G, Wilsgaard T, Rosvold Berntsen GK, Maltau JM, Kiserud T. Reference ranges for umbilical vein blood flow in the second half of pregnancy based on longitudinal data. Prenat Diagn 2005; 25: 99–111.

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Vimpeli et al. 2009

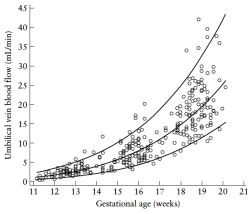

Figure 5 Umbilical vein volume blood flow at 11–20 weeks of gestation. The regression lines represent 5th, 50th and 95th percentiles.

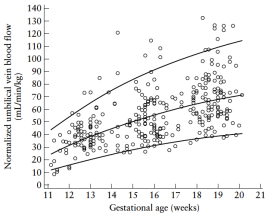

Figure 6 Umbilical vein volume blood flow normalized by estimated fetal weight at 11–20 weeks of gestation. The regression lines represent 5th, 50th and 95th percentiles.

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Vimpeli et al 2009

Table 1 Repeatability of volume blood flow measurements

Parameter	*Intraclass correlation coefficient (95% CI)*	*Repeatability coefficient (95% CI)*
11–13 weeks		
Q_{uv}	0.98 (0.94–0.99)	0.53 (0.36–0.96)
LVCO	0.93 (0.77–0.98)	1.61 (1.13–2.83)
RVCO	0.94 (0.80–0.98)	1.68 (1.15–3.06)
18–20 weeks		
Q_{uv}	0.97 (0.91–0.99)	0.06 (0.04–0.11)
LVCO	0.82 (0.45–0.95)	0.29 (0.20–0.27)
RVCO	0.93 (0.77–0.98)	0.16 (0.11–0.28)

LVCO, left ventricular cardiac output; Q_{uv}, umbilical vein blood flow; RVCO, right ventricular cardiac output.

Repeatability coefficient

1.96*V2*within-subject SD

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Matters Arising

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