Obstetrical Doppler

Emanuel P. Gaziano, M.D.

Obstetrical Doppler technology is an extension of ultrasound, which allows information to be obtained from the fetal circulation, allowing the visualization of fetal blood flow in real time. Obstetrical Doppler allows the accurate identification of the fetus at risk for chronic lack of oxygen and is an essential tool in the management of fetal growth restriction. We will review the physics and technical considerations of obstetrical Doppler and describe its clinical application.

The placental and fetal circulation allows the delivery of well-oxygenated blood to the fetus. The fetal blood, which already has oxygen extracted from it, returns to the placenta through the two umbilical arteries which course around the fetal bladder and exit into the umbilical cord (Figure 1). Obstetrical Doppler can study any portion of the fetal circulation.

The Doppler Principle

The Doppler principle is based upon the difference between the transmitted frequency and the received frequency of sound. We experience this principle of physics almost daily in our lives when we note the difference in sound when a car comes towards us compared to when the car is going away from us. Present ultrasound technology permits the measurement of blood flow velocity using Doppler detected changes in the speed of sound of red blood cells as they are scattered back from an ultrasound beam. Real time images are received and expressed as a flow velocity waveform which mirrors the cardiac cycle (Figure 2).
This display of the waveform and its analysis is termed “spectral” Doppler. Examination and measurement of the relationship between the systolic component and the diastolic component permits an assessment of the downstream resistance (impedance) to blood flow. When the red blood cells are encoded with color, Doppler color flow mapping of the fetal circulation is possible when 2D flow in certain blood vessels is superimposed on 2D ultrasound images of the anatomy. These images essentially “color” the blood vessels of interest and allow the determination of the presence and direction of blood flow (Figure 3).

Figure 3: Doppler color flow of blood flow in the fetal umbilical cord, liver and heart.

Indications for fetal Doppler include maternal or fetal conditions associated with abnormal placental vascular architecture. These include hypertensive complications of pregnancy or in suspected fetal growth restriction. Maternal auto-immune vascular disease and the antiphospholipid syndrome as well as diabetes with vascular disease all qualify for conditions in which placental abnormalities are high.

Clinical Use of Spectral Doppler
When the flow velocity waveform is recorded, each blood vessel has its own signature waveform. That is, the flow velocity waveform of the umbilical artery looks different from the flow velocity waveform of the descending aorta. The waveform reflects the downstream resistance to flow and these waveforms can be described by indices, S/D (systolic/diastolic) ratio or a resistance index (RI), which can be measured and demonstrate the relationship between the systolic and diastolic components of the cardiac cycle. An arterial waveform, which has little flow in diastole, would have a high S/D ratio or a high resistance index and would indicate a high resistance to flow downstream.

The Umbilical Artery
The umbilical artery was the first blood vessel studied and yields the most information. Spectral blood flow waveforms, which show an increased resistance in the umbilical artery, reflect downstream resistance to flow. Since the placenta is “downstream” from the umbilical artery, increased umbilical artery Doppler resistance is a sign that the placenta is abnormal in its blood vessel architecture. Therefore, umbilical artery Doppler waveform assessment is an accurate test of placental sufficiency and function. Women with hypertension or preeclampsia, for example, may have pregnancies complicated by abnormal vasculature in the placenta. By studying the umbilical artery Doppler waveform, accurate assessment of placental adequacy is possible. The umbilical artery resistance normally falls with gesta-
Abnormal values in the umbilical artery not only reflect placental function and are associated with growth restriction but they are also seen in fetuses with karyotype abnormalities such as Trisomy 13 and Trisomy 18. Abnormal Doppler values are also present in the placentas of babies who have malformations when the placentas are themselves abnormal. Extreme abnormal findings precede fetal death or abnormal heart rate tracings and are accurate indicators for the need for delivery. Additionally, a number of studies demonstrate that abnormal Doppler values (Figure 6) predict the length of stay in newborn intensive care units.

(Figure 4) Changes in umbilical artery S/D ratio with gestational age. (Figure 5) Normal umbilical artery waveform. (Figure 6: Abnormal Doppler waveform of the umbilical artery. Note the little flow in diastole. This would be a high resistance S/D ratio or Resistance index (RI) and would indicate that placental insufficiency exists and that close fetal surveillance is warranted.)
In the diagnosis of fetal growth restriction, both ultrasound estimated fetal weight and umbilical artery Doppler results, can be used together and the positive predictive value for fetal growth restriction is approximately 77 percent. The use of Doppler in pregnancies complicated by suspected growth restriction has resulted in a 38 percent decrease in perinatal mortality. In the Cochrane database of 11 trials with over 7,000 patients, the trend suggests a reduction in perinatal death when fetal Doppler is used to manage pregnancies at risk for placental insufficiency.

**Doppler Values and the Management of Growth Restricted Babies**

How can the umbilical artery Doppler values and middle cerebral artery Doppler values be of benefit in the management of growth restricted babies? As noted previously, the umbilical artery Doppler result, if normal, suggest that blood flow in the placenta is normal. If one suspects growth restriction by clinical or ultrasound means and the estimated weight of the fetus is less than the 10th percentile for gestational age, these babies are potentially at risk and deserve close follow-up. In addition to the routine non-stress testing and biophysical profile testing, umbilical artery Doppler monitoring of the growth restricted fetus becomes important. In the presence of a normal Doppler value with growth restriction, outcomes are generally good and intervention is not necessary. When the umbilical artery Doppler value becomes abnormal, the degree of abnormality can be measured by the resistance index such as the systolic to diastolic (S/D) ratio or the resistance index (RI). Progressive increase in the resistance of the umbilical artery suggests placental malfunction or insufficiency and again histological studies of such placentas show abnormal blood vessels in the placenta itself. The abnormality in the umbilical artery can progress to the absence of blood flow during the diastolic or heart filling component of the cardiac cycle. These babies are particularly vulnerable and are at high risk for intrauterine fetal death or fetal distress during labor. When there is reversal of flow in diastole (Figure 7) fetal death can occur within days of such findings.

**Middle Cerebral Artery**

The second important blood vessel studied with spectral Doppler is the middle cerebral artery. The “resistance” of the middle cerebral artery, a branch of the Circle of Willis in the brain, is generally higher than that of the umbilical artery. Flow velocity waveforms characteristic of the middle cerebral artery can be easily obtained with spectral Doppler. While the waveforms of the middle cerebral artery will normally show high resistance, if the waveforms show a low resistance pattern, it suggests that the baby is shunting more blood to the brain at the expense of other organs such as the liver. When this occurs, “brain sparring” effect is taking place and may be a sign that the fetus is compensating for a borderline state of oxygenation.
OBSTETRICAL DOPPLER

As the placenta deteriorates in these pregnancies, a change in the resistance of the middle cerebral artery can be detected upon serial measurements. The resistance index of the middle cerebral artery should always be greater than the resistance index in the umbilical artery. When the resistance index in the middle cerebral artery is lowered to below that of the umbilical artery, blood flow redistribution is said to occur, which is a compensatory adjustment by the fetus and requires close surveillance. Doppler measurements on the venous side of the circulation can give us information relative to right-sided heart failure and may also help in determining the time of delivery.

In summary, fetal spectral Doppler allows the interrogation of arteries and veins in the fetus. This information determines placental insufficiency and whether or not there is redistribution of blood flow to the fetal brain. Spectral Doppler waveforms are useful because they have few false positive results and are usually accurate in determining adverse fetal conditions. Certain waveform patterns are indicative of fetal jeopardy suggesting delivery of these babies before adverse outcomes occur.

The following material was developed prior to RGA’s acquisition on January 1, 2010 of the Group Reinsurance Business formerly owned by ReliaStar Life Insurance Company (a subsidiary of ING Groep N.V.) If you have questions, please contact RGA.

Figure 7. Reversal of diastolic flow in the UA, a sign impending fetal demise.

The next two figures (8, 9) demonstrate how studying the waveforms in the middle cerebral artery may be helpful in assessing the fetal compensatory adjustment to chronic lack of oxygen. The umbilical artery waveform is almost always abnormal when there are compensatory changes in blood flow to the brain.

Figure 8: High resistance (normal waveform) of the middle cerebral artery

Figure 9: Lower resistance (more diastolic flow) suggests the fetus is demonstrating blood flow redistribution, a sign of fetal stress

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Calculating return on investment from disease management (DM) programs is a challenge for health plans. It is the source of more misconception than any other aspect of DM. This article will identify and explore the misconceptions, provide some definitive rules for measuring returns from DM programs, and finally provide a case for outsourcing for DM services.

Do DM programs save money?
The answer to this question may be quite different for the two major sources of programs – homegrown (internal) and outsourced.

Homegrown Documenting measurable savings is difficult for many homegrown DM programs. Implementation can take 18 months, according to Sally Duran of MidAtlantic Medical Services Inc. (MAMSI). Staff must be added, enrollments are uncertain for the simple reason that unlike vendors, most homegrown programs don’t budget for enrollment specialists, and few homegrown plans even measure the savings they achieve on a claims basis. Usually clinical or self-assessment indicators are measured, rather than financial results. When financial results are measured, it’s often on the subset who actually took the initiative to enroll, by far the easiest group of people to improve.

Outsourced However, outsourced disease management – defined more broadly as outsourced medical management – is the single largest source of untapped savings available to most health plans today. Health plans that know how to contract for disease management programs using guaranteed savings in their contracting and avoiding all major sources of biostatistical bias can realize savings in excess of two percent of total medical losses by the second year (four percent in Medicare). Yes, these programs do need to be undertaken anyway for compliance and marketing, but that is no excuse for not saving money on them.

Will the Chief Financial Officer believe the reported savings?
If the vendor makes a hard guarantee of a specific level of savings in excess of fees and agrees to biostatistically sound metrics to determine whether that specific level of savings is met, the savings are legitimate and the CFO should accept the argument. Most vendors know how to phrase their value propositions in terms that a CFO is familiar with.

How will plans pay for outsourcing disease management if they are experiencing a budget freeze?
Most health plans pay for these programs out of medical spending, not out of the administrative budget. Since all medical savings accrue “below the line” and because the savings are guaranteed, it is logical and fair to have the fees come out of medical spending as well.
Are reported savings from vendors just smoke and mirrors?

There are two major sources of “smoke and mirrors” in disease management outcomes measurement. One is regression to the mean, caused by selecting only moderately and severely ill members for inclusion in the program, where “moderately and severely” is defined as high utilizers in a previous period. Simply stated, last year’s high utilizers may not be this year’s high utilizers, whether or not a program is in place. By selecting on the basis of last year’s utilization, a program will automatically see improvement because of random variation. But that improvement is truly “smoke and mirrors,” because quite a number of other members who did not have emergency or inpatient claims last year will have them this year…thus increasing costs to offset the alleged reduction experienced by program participants.

This is especially a problem in chronic non-progressive diseases like asthma, and to a lesser degree chronic but more slowly progressive diseases like diabetes. In congestive heart failure any regression to the mean impact is probably outweighed by a secular underlying deterioration in the patient’s condition.

The other source of “smoke and mirrors” is sample selection bias caused by measuring the results of only the voluntary enrollees into a program and not the population of patients with the disease in question as a whole. Although less widely identifiable than regression to the mean, this is actually the faster-growing misconception. An excellent example of it is chronicled in the article: “This Disease Management Study is Flawed” in Managed Care, June 1999.

Several of the reputable vendors in this industry (27 out of the 160 total vendors) will agree to avoid both fallacies when pressed, but make sure to check the proposals and contracts carefully as there are many hidden sources of both, especially regression to the mean. For instance, a measurement based on “diagnosed” coronary artery disease (CAD) patients will show savings because about 30 percent of major CAD events happen in people who were not previously diagnosed. If CAD expenses rise 10 percent a year, that means that the claims incurred by previously diagnosed people drop 20 percent year over year, with the 30 percent new claims making up the difference.

What about vendor fees?

How much the vendor makes is irrelevant to how much a health plan saves. For instance, if a vendor says: “If you give me a dollar, I’ll save you $10,” you’ve made 10 times what the vendor has made. If a vendor says: “Give me 90 percent of your current medical spending and I’ll pay all your claims and guarantee improvements in health status and satisfaction,” the vendor has “made” (although they have costs too) nine times what you’ve saved.

But which program raises the stock price of the health plan?

Will you lose control of your members?

The sine qua non for effective control is information. We’ve all heard the cliches…“uncontrolled is unmanaged,” etc., and they’re all true. Prior to outsourcing, most health plans cannot even identify their patients with various diseases, let alone measure the quality and/or cost of their care. Once a contract has been initiated, however, health plans have a clear window into the care that these patients are receiving. They can then exercise “control” by enforcing protocols, reconfiguring networks, adjusting the benefits plan, etc. And the ultimate control – bringing the program in-house – is a possibility as well. Most DM vendor contracts are written with an “out” clause for the health plan should it choose to do exactly that…although only in a few cases has a health plan actually done that.

Would health plans save money by building their own disease management programs rather than outsourcing?

This question overlooks the incontrovertible fact that a vendor’s efficiencies learned from implementing essentially the same program many times far outweigh the extra elements in their cost structure.

There is also the “cost” of time. At a recent roundtable published in Healthcare Business Review, two experts in building and buying – MidAtlantic Medical Services Inc. (MAMSI) and Humana respectively – exchanged opinions. Humana said that it could implement a purchased program in six months, while MAMSI (as mentioned earlier) indicated that 18 months was par for the course when building.

There is also the “cost” of financial risk. “Buying” also allows savings to flow straight to the bottom line, provided it is done on a guaranteed basis.

There is also the “cost” of the marketing disadvantage in large account sales, which “built” programs bring with them. Arnold Milstein MD, who runs the healthcare practice of William M. Mercer, and Peter Lee, CEO of the Pacific Group on Health, are two examples of influential consultants who have gone on the record advising their employers to prefer health
(Continued from page 7)

plans with outsourced programs. Even Ms. Duran of MAMSI, who runs one of the most robust internally developed programs in network-model health plans in the country, acknowledges that selling against health plans with outsourced programs or directly-contracted outsourced programs, is an uphill battle.

Finally, there is the “cost” of physician relations when physicians are globally capped or at least share some of the inpatient risk. An outsourced program (particularly if physicians are allowed to participate in the selection and evaluation of such a program) is a much easier “sell” to those physicians than one in which they are asked to participate with no guarantee of success.

Those readers not persuaded by that logic should be persuaded by data. One would think that – with six hundred health plans and 10 disease-manageable disease categories (six thousand “cells”) – there would be quite a number of home-built programs announcing that they demonstrably save money across an entire population of people with a disease. Only two programs have done so: Kaiser’s ESRD program in southern California, and MAMSI.

What about implementing an outsourced disease management program?
Implementing the three most potent programs in the outsourcing arsenal saves a total of at least two percent overall in the under-65 population. Clearly nothing that promises results like those will be easy to implement, and yes, outsourced programs are hard to implement. Their implementation difficulties, however, recall some words from Winston Churchill: “Democracy is the worst form of government except for all the others that have been tried from time to time.” Likewise, DM programs are the hardest way to save four percent of medical losses except for all the others which health plans try from time to time.

Can small health plans benefit?
A 15,000-member health plan (including, to be fair, nearly 4000 Medicare lives) saved $1-million. The trick with small health plans: Do all four major chronic diseases and conditions (CAD, congestive heart failure [CHF], diabetes, and chronic obstructive pulmonary disease) of the over-50 crowd together, on one contract. Then you will be able to get a high-quality vendor’s attention far more effectively than doing one alone. The only trade-off is that you will have to spend a fair amount of money…but the more you spend, the more you will save in the same year.

Note: one might infer from this example that chronic disease management is most worthwhile in an older-than-average population. This is absolutely the case. CHF prevalence, for example, is five percent over age 65, but well under one percent under age 65. In an under-65 non-Medicaid population, respiratory, diabetes and CAD are the best bets for near-term savings.

Al Lewis is founder of the Disease Management Purchasing Consortium and the Disease Management Association of America, the industry’s lobbying arm and sponsor of the official annual industry conference.

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## Emerging Technologies and Innovative Approaches for Managing Patients with Complex Medical Conditions

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## Evolving Science of Blood/Marrow Transplantation and Cancer Treatments

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## Research on the Cutting Edge: Adopting Evidence for the Real World

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## National Conference of Neonatal Nursing

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## Course in Transplantation for Case Managers

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## Nephrology Annual Clinical Meeting
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## Traumatic Brain Injuries

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## CMSA 14th Annual Conference & Expo

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