Hi everyone. This is Dr. David Bluemke in Madison, Wisconsin. In this podcast, I'm going to summarize two reviews and two new research articles for you from the April 2018 issue of *Radiology*.

Before I go into more detail, I want to mention the RSNA trainee awards. These were given to trainees including residents and fellows giving abstracts at the most recent 2017 RSNA meeting in Chicago. Because the meeting is in Chicago, we would expect most trainees from the U.S. That of course, was the case. But the second place, or a silver medal, for the number of trainees went to China, with five trainee awards.

I previously summarized the high quality of manuscripts coming from China. The five awards cover the gamut of hot topics: Radioinformatics to detect portal hypertension, percutaneous vertebroplasty, myocardial ECV of the left ventricle, dose reduction with triple rule out CT, and a paper on MRI nanoparticles. Quite a range, and I would like to congratulate our winners from around the world. I expect that a number of these award-winning abstracts will be in *Radiology* as full publications in the coming months.

But here is a trivia question. The answer is, the year the Nobel Prize in medicine was awarded to an investigator from China. Now you form the question. What was the year 2015? I'm not going to push it further, but will just give you the rest of the story. China's Tu Youyou received the Nobel Prize in 2015 for extracting an anti-malarial drug from an herb used in traditional Chinese Medicine.

The Lasker Award in the U.S. is the equivalent of the Nobel Prize. Dr. Tu Youyou was awarded the Lasker in 2011 for the same discovery. The drug is called artemisinin. It is as an alternative malaria cure to the standard chloroquine. Chloroquine has lost effectiveness since the 1960s due to drug resistance. The story of discovery is interesting. During the Vietnam War, Ho Chi Minh was the leader of North Vietnam. He is said to have asked for Chinese help to develop a treatment for soldiers traveling along the Ho Chi Minh Trail. The majority of soldiers were developing chloroquine resistant malaria. The Chinese were said to have screened 240,000 compounds for effectiveness. Tu Youyou, at age 39, had the idea of researching traditional Chinese medicine for a malaria cure. She successfully extracted the effective compound artemisinin from sweet wormwood from a plant, tested it on animals, and herself. She presented the findings to the World Health Organization in 1981. Tu Youyou still lives in China, but her oldest daughter lives in the United States. The current first line treatment for uncomplicated malaria is artemisinin combination therapy, or ACT.

So, two other quick topics. If these podcasts are interesting, or you would like different topics, please feel free to let me know by email or Twitter. I'm sending out daily highlights about the journal on Twitter, and it would be good to hear from you. If you download PDFs of some the latest research, the newest articles that we are releasing are formatted slightly differently. The PDFs have the same familiar greenish-blue *Radiology* color, but there are two columns of text instead of three. I'm told it's easier to read and it also saves a few trees by being shorter. If you like it, please let us know.

That's it for the introduction, time to get on with the manuscript reviews. Let's go.

**Prostate Cancer: Improving the Flow of Research**


Colleen A. F. Lawton, MD

I want to first talk about a very nice – and short – article that at least 50% of you may want to read. The article is about prostate cancer, and our author gave the annual oration at the RSNA meeting in 2016. Dr. Colleen Lawton is a radiation oncologist at the Medical College of Wisconsin in Milwaukee. I have not personally met Dr. Lawton, but after reading this very clear and to-the-point article, I wish I had. Let me explain.

First, Dr. Lawton is from Milwaukee as I mentioned. I grew up outside of Milwaukee; my parents live about 10 minutes from the medical college. The radiology staff there is outstanding, and radiologists key to our field such as Dr. Dennis Foley have been long-time contributors to the journal.

Second, Dr. Lawton has managed to write a succinct, three-page article that provides a wonderful overview of state-of-the-art treatment and diagnosis of prostate cancer. I will summarize a few points, but her writing is so clear that you can get more detail by reading her article.

This is a summary. Both prostate cancer and breast cancer affect about 200,000 people in the United States each year. The fatality rate from breast cancer is somewhat higher. 40,000 women die annually from breast cancer and 27,000 men die from prostate cancer per year in the United States. Both cancers have screening tests: mammography and PSA testing. But access to mammography is a legal right in the United States, while PSA testing is not.

The U.S. Preventive Services Task Force has recommended against PSA screening. They give an “A” score to their highest recommendation and “D” to the lowest. PSA received a score of D, which means discourage use of PSA for screening. The USPSTF task force says reduction in prostate cancer mortality after 10 to 14 years is, at most, very small even for men in the optimal age range of 55 to 69 years. There is no reduction in all-cause mortality. All-cause mortality means you can get killed by riding your bike on the way to work, or you could be killed by prostate cancer.

Let's look more closely. The optimal cut-off for an abnormal PSA increases with age. Refinements on PSA testing include percent free PSA and PSA density. PSA density requires an ultrasound to measure prostate size, but otherwise PSA density and free PSA have similar sensitivity and specificity to detect cancer. A PSA level of 4 has a sensitivity of about 20% for cancer. The positive predictive value is 30%, or 1 in 3. That positive predictive value is probably about the same as mammography or a little higher. We discussed positive predictive value in an earlier podcast. If your test is positive with a PSA, there is about 1 in 3 chance that you actually do have cancer.
If prostate screening is performed, most of the time we have low-risk disease. This means the PSA level is less than 10 ng/ml, the Gleason Score is ≤ 6, and there is clinical T2a or less disease. First the Gleason Score. We discussed this on an earlier podcast as well. If a Gleason Score is 3 + 4 = 7, the first number is about the cells making up the largest area of the tumor. The second number is about the cells making up the second-largest area of the tumor. The lowest score of a cancer is 6, with a Gleason Score of 3 + 3. This means cells are well differentiated in both the largest and second-largest area of the tumor.

T2a disease means the tumor is in one-half (or less) of only one side of the prostate gland and does not have lymph nodes or metastases.

For low-risk prostate cancer, active surveillance may be the best for most men. This philosophy that the best treatment is no treatment started in the mid-1980s. At that time, I was at the University of Chicago, a young urologist there with this no-treatment opinion was considered radical. Remember that surgeons used to dominate cancer therapy. Massive cancer surgeries in the U.S. became synonymous with William Halstead at Hopkins, doing radical mastectomies for breast cancer.

So let’s say you are a 55-year-old man with low-risk cancer. The U.S. preventive health services indicates that over the next 15 years, your prostate cancer mortality is very small in this situation. You might equally well die from something else. So 55 years plus 15 years equals 70 years old. Well, I think if you are 55 years old now, you really hope you are going to live past the age of 70. And if you make it to age 70, your average life expectancy is another 15 years! Perhaps at age 82 you start to have lots of bone pain, your PSA goes up a bit, indicating your small cancer is growing, but you otherwise are healthy. You are anxious, your doctor is anxious, and you start getting a lot of testing, such as bone scans, more prostate biopsies, and more anxiety – since you know you have a growing cancer. At age 82, you are in worse physical shape than when you had your original diagnosis at age 55, and you are less able to tolerate hormonal or chemotherapy, let alone surgery.

Can we use MRI to give us more information for which individuals have low-risk cancer? The PI-RADS system may be one approach, suggesting potential lesion aggressiveness. For category 4 or 5 lesions, we can now perform directed biopsies, rather than random biopsies, looking for the higher-risk disease. PI-RADS scores evaluate T2 weighted images, dynamic contrast images, and diffusion weighted images to have a composite tumor score, from 1 to 5, with 5 being the most suspicious of malignancy.

Going back to PSA, if the PSA is greater than 10 ng/ml but less than 20, with a Gleason Score of 7 or more and T2B or C palpable tumor within the gland, you have intermediate risk prostate cancer. Treatment is either radiation or surgery. Which is better? The ProtecT trial was a phase III randomized trial for prostate cancer. 1,600 patients were randomized to surgery or radiation or active surveillance for organ confined disease. At 10 years, surgery and radiation therapy had no difference. The majority of patients who underwent active surveillance eventually had curative treatment. Do you want your treatment now at age 55, or would you rather put it off for another 10 years?

Finally, external beam radiation therapy has had many advances over the years. Radiation is better than surgery for urinary tract complications. Radiation, however, is worse for bowel abnormalities involving the rectum. By using 3D planning and image guidance, radiation therapy seeks to reduce these complications. Traditional radiation therapy required daily treatments for 8 to 9 weeks. That is really a long time. Using hypofractionation treatment, radiation treatments can now be cut in half, to 4 to 5 weeks.

Radiologic imaging will continue to have a large role in future advances in prostate cancer. Sodium fluoride PET/CT is extremely sensitive for evaluating bone metastases. New Carbon 11 choline PET/CT and other more specific tracers will improve tumor staging. Dr. Lawton also points out imaging needs to define the relationship of the urethra in the prostate prior to therapy, and improved detection of microscopic disease.

Overall, this is an excellent and short review article on a hot topic.

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Cerebral Microbleeds: Imaging and Clinical Significance


Sven Haller, MD, MSc, • Meike W. Vernooij, MD, PhD, • Joost P. A. Kuijer, PhD, • Elna-Marie Larsson, MD, PhD, • Hans Rolf Jäger, MD, FRCR, • Frederik Barkhof, MD, PhD

Our next topic is a review article from the April issue. The title is “Cerebral Microbleeds: Imaging and Clinical Significance.” The lead author is Dr. Sven Haller from Geneva, Switzerland. The senior author is Dr. Frederik Barkhof from Amsterdam. Both authors are frequent contributors to this journal and are well-known and are highly-respected. Dr. Barkhof is a current member of our editorial board as an associate editor.

The article is well written so that even a body radiologist can learn from this. Many radiologists are physics geeks, and the authors first discuss MRI pulse sequences. A cerebral microbleed is due to cerebral microhemorrhages. The pathology consists of iron in the form of hemosiderin, contained within macrophages.

Iron is paramagnetic. What is that? It means that when iron is placed in a magnetic field, the local magnetic field around iron is actually slightly increased. What is the opposite of paramagnetic? Some materials cause a decrease in the magnetic field. They are called diamagnetic. Diamagnetic substances oppose the magnetic field. What’s the most common diamagnetic material in the body? Water. There is a very cool video on YouTube showing how you can set up your own magnetism experiment in your kitchen sink. You put a magnet near a tube of water, and show that the water moves away from a strong bar magnet. That’s kind of cool, but it is a sort of messy experiment. Instead, you have seen those interesting desk ornaments, where a piece of material is levitated. That levitation effect is due to diamagnetism. Quite interesting, but more expensive than the experiment in your kitchen sink. By the way, other than water, the other diamagnetic material in the body is calcium.

Back to the main topic. Microbleeds in the brain can be detected using either T2* gradient echo sequences or susceptibility weighted images. Let me refresh your memory just a bit about these.
A T2* sequence is about the simplest MRI sequence that we have. The scanner tips the magnetization partially into the horizontal plane. Then the magnetic gradients are reversed. The spins refocus and form a gradient echo. Most of the time we are interested in T2, describing the rate of decay of transverse magnetization. But we don't actually get T2 unless we use a faster spin echo pulse sequence with an extra 180-degree pulse. Instead, the simpler GRE pulse sequence gives us a more rapid T2 decay, called T2*. T2* results from local magnetic inhomogeneities. The local variations in the magnetic field cause transverse signal to decay very rapidly. In the case of cerebral microbleeds, small areas of iron in macrophages cause local disturbances in the magnetic field. Microbleeds show up as black dots, but can be up to 5 or 10 mm in diameter. You ask the MRI tech to give you a more T2*-weighted image by using a longer TE time. For example, instead of 20 msec, you have a more T2* effect if the TE time is 40 msec.

The more advanced way to look at microbleeds is with susceptibility weighted images, or SWI. SWI is one of the few pulse sequences in MRI where both the phase and magnitude of the MRI signal is used. Usually we use only the magnitude, or brightness of the image. Not surprisingly, the phase information contains information as well. The phase change in the region of iron in microbleeds is very different from the normal surrounding brain tissue. SWI has two steps.

The first step is to process the phase image. You have seen phase images before. They look messy, with waves of black and white signal throughout the images. This is usually why we discard them. They need extra processing. The first processing step is to get rid of the big waves of signal. This is done using a high-pass filter. High-frequency changes are retained, and the big waves are removed. The phase images now look much more uniform – except for the phase changes in the microbleeds. Quiz question at the end: What other MRI sequences combine magnitude and phase images? I'll reveal this secret at the end of this discussion.

For SWI: The next step is to multiply the phase images times our normal T2* magnitude image. Combining the phase abnormalities from the microbleed with the T2* image will greatly accentuate the dark spots in the image. About twice as many microbleeds are seen in SWI compared to T2* images.

The problem is that SWI dark spots are not specific. There are also phase changes from calcium. As you know, the pineal gland is often calcified. We have an upcoming research article in this journal that addresses pineal gland calcification. But for now, both calcium and iron cause dark spots in the brain on SWI and T2* images.

How do you tell the difference? Diamagnetism. Calcium is diamagnetic – it opposes the main magnetic field. Iron is paramagnetic. On the phase images, one of these produces a dark spot, the other produces a white spot. Interestingly, calcium, as dark or bright, depends on who makes your MRI scanner. They are not consistent. It turns out that Siemens uses one approach, while GE and Philips use the other.

But you can just look at the images and tell which is which. On the phase image, if venous blood in the sagittal sinus is bright, then the microbleed is also bright. Calcium is dark. And the opposite holds as well. A little annoying, but not difficult. You could double check a CT scan of the brain, if the calcium is big enough.

Enough physics. Here are 10 major points about microbleeds from this review article.

Point number 1: microbleeds are relatively stable over time, sort of like a tattoo from iron in the brain. But like tattoos, there is some evidence that a small number of microbleeds might go away after many years.

Point 2: You can grade the severity of microbleeds by eye. But quantitative susceptibility mapping, or QSM, is a method to derive the true magnetic susceptibility. It is a difficult technique and used only now in research.

Point 3: When compared to autopsy brains, SWI images find not only about one-half of the microbleeds. If you use 3T or 7T, you will find more microbleeds than at 1.5T.

Point 4: In healthy control subjects, there is no clear correlation between the presence of microbleeds and cognitive symptoms.

Point 5: the number of cerebral microbleeds increases with age both in individuals who are healthy, as well as those with dementia.

Point 6: Besides age, hypertension and male gender are associated with more cerebral microbleeds.

Point 7: Alzheimer’s disease and cerebral amyloid angiopathy both have more cerebral microbleeds than normal individuals. Cerebral amyloid angiopathy deposits are lobar or more peripheral. This is also the case for Alzheimer’s.

Point 8: Hypertensive microbleeds are deep, in the thalamic regions. These locations are characteristic and distinguish hypertensive microbleeds from other causes.

Point 9: Traumatic brain injury shows cerebral microbleeds in the corpus callosum, and have a more radial configuration.

And lastly, point number 10: There are many other causes of microbleeds. Some of these include cavernous angioottasias, radiation therapy, micrometastases, and moyamoya disease.

Dr. Haller and his colleagues have assembled a very nice review article and the images are quite helpful. If you want a quick review of the physics MRI principles that I discussed, I suggest you look at Dr. Allen Elster’s website. Dr. Elster wrote a wonderful book that was initially published in 1994, called, “Questions and Answers in MRI.” I used to advise all of our trainees to get this book. He has now given back to the radiology community. The entire book is free online. You can review these topics in a few minutes. Each section starts with a question, such as, “What is SWI?” An approximately one-page answer follows, with images and graphics. It is outstanding.

Finally, the answer to my quiz question. Besides SWI, in what MRI pulse sequence is the phase information combined with magnitude information? The answer is cardiac MRI. LGE, or late gadolinium enhancement, show small scars from myocardial infarction in the heart. However there are other artifacts. Image quality is usually improved using phase sensitive inversion recovery LGE images. At our hospital, the phase sensitive method is used daily for our cardiac MRI cases.
Digital Breast Tomosynthesis with Synthesized Two-Dimensional Images versus Full-Field Digital Mammography for Population Screening: Outcomes from the Verona Screening Program


Francesca Caumo, MD, • Manuel Zorzì, MD, • Silvia Brunelli, MD, • Giovanna Romanucci, MD, • Rossella Rella, MD, • Loredana Cugola, MD, • Paola Bricolo, MD, • Chiara Fedato, MD, • Stefania Montemezzi, MD, • Nehmat Houssami, MD, PhD

Our first research article for this session is regarding breast imaging. The short title is, “Digital Breast Tomosynthesis with Synthesized 2D Images versus Full-Field Digital Mammography”. The study was conducted in Verona, Italy. The lead author is Dr. Francesca Caumo.

The background is that breast tomosynthesis plus standard 2D imaging has shown improved cancer detection rates relative to 2D mammography alone. However, if you obtain 2D digital mammograms plus tomosynthesis, the radiation dose is about twice that of standard 2D imaging. As an alternative, one could use computer techniques and combine the tomo images, to create a synthetic 2D image.

What do the synthetic 2D mammograms look like? Well, not exactly like a standard mammogram. But maybe it does not have to look the same, the synthetic image just has to perform the same as better. To make a synthetic 2D mammogram, one manufacturer starts with 1 mm tomographic slices. Features such as calcifications and linear structures are identified and given stronger weighting in the combined 2D image. This is an excellent idea that has been validated in early clinical studies.

How does it work in practice?

Ideally, we would like prospective multi-center clinical trials, with patients randomized to having either synthetic images or standard 2D images, in addition to tomosynthesis. Those are not yet available. First, such a trial is extremely expensive, and it takes a long time to get funding and start and complete the trial.

Second, cancer detection rates are 5 to 10 per 1,000 patients. So just to get 100 cancers (which is kind of small), you need 20,000 patients in each group. Finally, after all of this is accomplished, synthetic 2D images are a new technology. Breast imagers have to learn to read them. And the technology is prone to change over time.

In the meantime, the authors of this current study deployed synthetic 2D imaging plus breast tomosynthesis in their area of recruitment in Verona. They evaluated the cancer detection rate in a one-year period of time. Their comparison group was a historical control. The cancer detection rate from the one year prior to deploying synthetic 2D images.

Results: In the group with synthetic 2D images, there were 16,666 patients. In the one year before that with only digital mammo, there were 14,423 patients.

What happened?

There are two main outcome measures. The first is the cancer detection rate. With synthetic 2D images plus tomo, the cancer detection rate was 9.3 cancers per 1,000 women screened. With digital mammo only, the cancer detection rate was lower: 5.4 cancers per 1,000 women. The difference was statistically significant.

In Italy and other parts of Europe, breast cancer screening is very different than in the U.S. Patients have their screening mammography and all scans are double read, two separate breast imagers reading independently. If either person thinks there is an abnormality, then the patient is recalled for more imaging.

With that background, the results of the recall rate were particularly interesting. The recall rates for digital only were statistically the same as for tomosynthesis plus 2D synthetic images: about 4% for both. So if the same percentage of patients was recalled, but almost twice as many cancers were found with 2D synthetic images, that means there were many fewer false positives with the new method.

For cancer screening, an important metric is the positive predictive value. The positive predictive value has some shortcomings. But it is easy for patients to understand. If the screening mammogram is positive, the positive predictive value is the likelihood that you really will have cancer. The positive predictive value for synthetic 2D images plus tomo was 23%. For standard digital mammography, the positive predictive values was only 13%. The differences were statistically significant with p<0.001.

Finally, there was one other peculiar and possibly very nice positive finding. The authors evaluated the types of cancer found by standard imaging vs. 2D synthetic images plus tomosynthesis. The 2D synthetic images were 60% more likely to find invasive cancers.

What about reader performance? In Italy, two readers read all the cases. If only one of the two readers found the cancer, the authors define this as a disagreement. Only 7% of the cases were disagreements with synthetic images plus tomosynthesis, versus 28% with standard 2D digital mammography. These results suggest that in the future, maybe two readers will not be necessary.

Finally, radiation dose between tomosynthesis plus 2D synthetic images and standard digital mammography were about the same. A big disadvantage was that it took longer to read the tomo and the synthetic images, and 10 times more data storage was needed. Data storage is actually inexpensive, but it still takes time to display the images and they must be permanently archived.

Overall, this is a large vote of confidence for synthetic 2D images generated from tomosynthesis images. There are important limitations of course. We cannot be so sure that the new method is better, since only a historical comparison was made to the prior year’s patients. There are strong biases that can creep in to affect the results. For example, there could be changes in health care policy from one year to the next. That happens a lot in the United States right now. There could be a story in the news about radiation exposure. We really don’t know. Therefore, we need a randomized prospective clinical study. Dr. Etta Pisano from Beth Israel Deaconness puts this study into perspective. She also tells us about a trial that will try to be more definitive. The TMIST trial of tomosynthesis sponsored by the U.S. National Cancer Institute. The study seeks to enroll 165,000 women at 100 centers in the U.S. and Canada. That is a lot of patients, but there are 50 million screening mammograms each year in the U.S. It seems worthwhile. Women are randomized to tomosynthesis or digital mammography screening. Dr. Pisano is the study PI. These types of studies are huge efforts. The full study results expected in about five years.
Fractional Flow Reserve Estimated at Coronary CT Angiography in Intermediate Lesions: Comparison of Diagnostic Accuracy of Different Methods to Determine Coronary Flow Distribution


Satoru Kishi, MD, • Andreas A. Giannopoulos, MD, • Anji Tang, BS, • Nahoko Kato, MD, • Yiannis S. Chatzizisis, MD, PhD, • Carole Dennie, MD, • Yu Horiuchi, MD, • Kengo Tanabe, MD, PhD, • João A. C. Lima, MBA, MD, • Frank J. Rybicki, MD, PhD, • Dimitris Mitsouras, PhD

The next topic affects potentially all men and women over the age of 50 years old. Ischemic heart disease from atherosclerosis is the world’s leading cause of death and disability. As the population ages, and with increasing control of infectious diseases and cancer, coronary artery disease has spread throughout the world.

The short title of the paper is, “Fractional Flow Reserve at Coronary CT in Intermediate Lesions: Comparison of Different Methods.” The first author is Dr. Kishi from Tokyo, Japan. Other authors are from Brigham and Women’s Hospital, Johns Hopkins, University of Nebraska, and Ottawa, Canada.

What is the background? We use noninvasive MRI and CT to screen for vascular disease throughout the body. Except, right now, for the coronary arteries. I think this will change in the next five years. Previously, cardiologists did more coronary CT angiography than radiologists. That is changing as well. Dr. David Levin at Jefferson showed data at the SCCT meeting a year ago that radiologists were performing the most coronary CT angiography. This is due to the increasing awareness of CT for coronary arteries, and the prevalence of 64-slice scanners.

The problem with coronary CT is that the positive predictive value is low. If the test is positive, the patient has only a 50% chance that the coronary narrowing is clinically significant. Do you want to send so many negative patients to the cath lab? It seems to me that cardiologists would lose confidence in your abilities. But it’s not your ability – at least I hope it is not. The problem is that narrowing by itself does not mean that lesions results in decreased blood flow. The coronary arteries are too small right now for coronary narrowing to be accurately depicted on CT.

So, we combine coronary CT results with something else. Very often, we have a coronary lesion that looks to be about 50% narrowed. We are unsure of the clinical significance. We magnify the images and take a look from every angle. But it does not help. It’s about 50% narrowed, plus or minus 20%.

Two solutions. The first is to do a stress test. This can be done with CT perfusion stress. It can be done with nuclear medicine, or exercise. Whatever your clinicians have confidence in.

The second solution is called CT FFR. FFR stands for fractional flow reserve. Right now, if you see a narrowed coronary artery, the patient gets a coronary catheterization. The interventional cardiologist puts a wire in the coronary artery of interest by the narrowing. He or she measures the pressure just before the narrowing. Then that person measures the coronary pressure just past the narrowing. The pressure is expected to be lower past the narrowing. If the pressure after the narrowing is 60 mm of mercury, and before the narrowing it is 100, the FFR is 60 divided by 100, or 0.6. Well, the magic cutoff is 0.8. If the pressure drop is 0.8 or less, the interventional cardiologist will dilate that vessel and place a stent. This numbers-based treatment is a little controversial. But that’s what happens most of the time. 0.8 you get a stent.

So, more background: it turns out that one can mathematically analyze the coronary CT arteries, and derive a CT-based fractional flow reserve at rest, with no stress agents. How is that done? Well, think about flow in a garden hose. There is pressure from the spigot and some resistance to flow down the hose. But not that much. Next, crimp the garden hose. You know that you can very predictably control the amount of water past the crimp in the hose by narrowing the bending. If it’s that predictable, that translates into writing an equation to predict the flow in the hose, based on the upstream pressure, the viscosity of the water, and the narrowing in the hose. The equations that describe the flow of fluids are called the Navier-Stokes equations. Every engineering student knows of them. They were discovered in 1822 by Claude-Louis Navier, and Sir George Stokes. Today, if you Google software algorithms for solving these equations, you get 540,000 hits. They are very popular equations. They have been applied to model the weather, ocean currents, airflow over a wing, water, and fluid flow, and even in video games to make motion realistic. Why not CT flow?

So, here is some specific background. Today, you can perform a coronary CT angiogram, you then pay a fee to a company called HeartFlow to do an FDA-approved coronary CT fractional flow reserve. The company has done an outstanding job at conducting clinical trials for CT FFR. CT FFR using HeartFlow methods outperform CT using coronary narrowing alone by about 20%. The method reduces false positives. HeartFlow’s initial algorithms solved the Navier-Stokes equations for you, and can improve your diagnostic accuracy compared to your looking at the coronary narrowing and measuring it.

But it turns out there are several different ways to solve the problem of a pressure gradient drop. There are two different formulas available to estimate coronary flow in relationship to the coronary artery diameter. The third way is different. It is called TAG, or transluminal attenuation gradient. TAG is the rate of change of the luminal attenuation versus the distance from the coronary ostium. If there is a tight coronary artery stenosis, the coronary attenuation decreases rapidly past the stenosis, the flow is low.

Methods: The authors studied 63 patients with intermediate coronary lesions, ranging from 25 to 69% stenosis. They calculated the CT fractional flow reserve from the CT coronary angiogram. The used the two traditional equation-based methods. They also used the TAG method. Then they solved the Navier-Stokes equations using standard computer software.

The authors compared their CT FFR results to results from the cath lab for invasive FFR. Interestingly, the newer TAG method outperformed the theoretical equation-based methods. To give you an idea, the AUC or area under the curve for the TAG method was 0.95. You recall that the maximum is 1.0. The other 2 equation-based methods were about 0.88. For all three CT FFR methods, there was a huge improvement compared to just looking at the narrowing alone. For example, the sensitivity of narrowing alone was 50% to predict a treatable
lesion in the cath lab. But the CT FFR methods all had a sensitivity on the order of 90%. A huge difference.

So this is quite interesting, and of course there are limitations. The most important limitation is that the TAG method will only work on a CT scanner when the entire coronary tree can be scanned in a single heartbeat. Otherwise, the gradient of contrast along the coronary artery cannot be estimated in two or more heartbeats. The authors indicate the method with TAG is relatively easy, so you can calculate CT FFR at your own site. But it’s not really easy unless you have really smart researchers like these. Most sites want to use commercial providers with FDA 510(k) approved software.

Dr. Jonathon Leipsic from Vancouver leads an editorial on this topic. Dr. Leipsic is rock star in the field of coronary CT angiography. He has done dozens and dozens of research studies on coronary CT and is a past president of the Society of Cardiovascular CT. He also points out that artificial intelligence algorithms are being developed. These seem destined to be the future approach, using cloud-based supercomputer algorithms. I must agree. This is a super-hot topic and there is a high likelihood you will be directly affected by these types of results. For the men, coronary artery disease will happen about 10 years before the women who are out there. You can read Dr. Leipsic’s editorial in the April issue of Radiology.