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MEDICAL AND PHARMACEUTICAL NETWORK NEWSLETTER

September 2007

Dear Colleagues,

The focus for this issue is the workshop on Medical Imaging held at Southmead Hospital in Bristol on 11 May 2007. On that occasion, as a departure from our usual practice, we did not send out texts in various languages for delegates to work on in advance. Instead we were fortunate enough to enlist four expert speakers who each covered a different aspect of this broad topic, giving us an intensive 1-day course of lectures. I know you will be particularly grateful to Brian Carter, Neil Paget and Ines Hegglin for their summaries of the first three lectures from the workshop.

An account of the fourth lecture will appear in a pre-Christmas issue of the Newsletter, together with a range of multilingual glossaries compiled by Karin Band and based on the speakers' terminology from all four lectures.

Our series of workshops has been running now for more than 20 years and the benefits to MedNet of these excellent CPD events are incalculable. Moves are afoot to hold one more workshop in 2007, with plans already at an advanced stage for a further event in Spring 2008. Details will be posted soon on the e-group. So that members who cannot attend can be 'virtual delegates', there is an ongoing need for volunteers to write up the speakers' presentations and for rapporteurs to record and submit the terminology from the various language groups. Thank you to all those who have done this so splendidly in the past and thanks to all those who will volunteer in the future … and believe me, you will, you will!

David Beattie

Medical Imaging Workshop

Southmead Hospital, Bristol
(11 May 2007)

Lecture I: Renal and Urinary Tract CT

Speaker: Dr Mark Darby, Consultant Radiologist

In the investigation of a clinical scenario involving the urinary tract, ultrasound is used initially and is very useful for screening. Computed tomography (CT) is then performed for more detailed investigation (the prostate is usually investigated by magnetic resonance imaging [MRI]). I have highlighted some terminology in bold.

The main clinical uses for CT are:

- Staging of malignancies or unusual presentations, such as primary renal cell carcinoma and transitional cell carcinoma (TCC) affecting the collecting system, ureters, and bladder.
- Infections, such as pyelonephritis, e.g. if abscess is suspected.
- Complex vs. simple cysts: simple cysts are fluid-filled but complex cysts may contain septa and be partly calcified; it is necessary to try to exclude Ca.
- Renal colic: more efficient than intravenous urography (IVU) X-ray.
  Dr Darby described spiral CT scanning, where the patient lies on a table that moves into the scanner, which then rotates around the patient. Less claustrophobic than MRI. Many 'slices' are produced with each rotation; thin slices, with smaller gaps than in older types of scanning. Can pick up tiny stones.
- Trauma – e.g. haematuria following trauma is CT scanned to ascertain whether surgery is needed.
- Angiography – for visualising the renal vessels.

The main advantages of CT:

- It uses less radiation whilst visualising larger areas.
- It gives good **spatial resolution** (the ability to pick up fine detail and define two structures very close to each other). Determined by factors such as slice thickness and number of samples.
- Good **contrast resolution** (the ability to differentiate two types of tissue with differences in contrast within an organ, e.g. tumours in liver). Determined by mAs (milliamps/sec = dose) and number of samples/projections.
- It is not organ-specific (e.g. looking for renal Ca but also including lungs for possible metastases).
- Large range of clinical applications (the images can be computed into 3D effects and then viewed in different planes – e.g. coronal and sagittal) ['**multislice'** means several images obtained on one rotation whereas '**multiplanar'** refers to the 2D reconstructions using multiple slices].
- CT scanning is easily obtainable and quickly performed.
- It is possible to scan the whole body for metastatic disease.

The disadvantages are:

- Relatively high dose of radiation, therefore must have strong clinical indications.
- Patients with renal impairment – can be made worse by administration of contrast.
- Necessity of i.v. contrast medium (high density contrasts with soft-tissue densities, especially in vessels): essential in abdominal CT.

Density is measured in **Hounsfield units** and the range is from minus 1000 to plus 1000. CT uses a relatively small range. Water is one unit, fat is less dense, soft tissues 40 to 50. The scanner can be set to concentrate on this smaller range of differing densities by techniques such as '**windowing**' and '**centering**'.

Contrast media:

- Potential problems with allergies, diabetes and asthma.
- Renal function (difficulties where serum creatinine > 120 μmol/L).
- Contrast-induced nephropathy – a disease induced by the medium itself.
- Use of non-ionic dimer agents such as Visipaque 320 – safer, less nephrotoxic.

Dr Darby showed 2 CT scans through the abdomen in **axial view** showing normal kidneys and other organs (slices are described as if the viewer is standing at the patient's feet, so the patient's left is on the viewer's right). He explained how water appears black, so structures containing a high proportion of water are darker (e.g. gall bladder), whereas fat is greyish and bone is white. Contrast reaches the renal cortex 40 seconds after injection, the medulla after 2–3 minutes, and passes down the ureters after 5–10 minutes. Next, a **coronal scan** (**multiplanar coronal reconstruction**): the plane can be rotated to follow the angle of the kidney – normally the lower pole lies more anteriorly. A **sagittal view** may be needed to clarify details.

General points about technique, reinforcing some of the above points:

- Spiral CT is used almost universally.
- Reduces mis-registration problems, e.g. through respiratory movements, children, fewer artefacts.
- Enables **acquisition** in one breath-hold, importance of good breath-hold technique.
- Sufficient mAs to achieve good penetration and contrast resolution.
- Fairly narrow slice width for good spatial resolution.
- Oral and i.v. contrast media.

Renal cell carcinoma – technique

- The most common renal malignancy.
- Oral preparation (500 ml of 2%–3% solution); start drinking this one hour before scan, to fill large bowel and distinguish this from kidneys.
- Non-contrast through kidneys (= **plain scan**, = non-enhanced scan) shows calcification.
- Positive i.v. contrast through upper abdomen to bottom of kidneys, 3 mm **collimation** (describes thickness of axial scan field) [the terms '**slice**' and

'**section**' are interchangeable in this context]. (Scans of 1 mm are needed for inner ear fine detail but need higher dose of radiation.)
- 60 sec delay to show cortex, 5 minutes to demonstrate collecting system.
- Chest scanned for metastases.

Scans illustrating renal cell carcinoma demonstrated the clear differentiation between cortex and medulla. Peri-renal fat plainly seen but not the surrounding (Gerota's) fascia. Metastases in the lungs detected as rounded nodules, soft tissue densities, by changing the density range.
Scanning excludes spread into adjacent fat but the presence of renal vein involvement is important to the surgeon.
The terms clot or thrombus here are actually jargon for 'tumour extension', '**tumour thrombus**' – synonymous terms for 'filling defect'. Detached pieces travel to the lungs, which is why one looks for metastases in the lungs first.

CT in bladder carcinoma
- Staging for local and metastatic spread, probably following cystoscopy and biopsy, with 5 mm slices of chest, abdomen and pelvis.
- Pre-contrast scan of bladder for calcification.
- Narrow slices through pelvis post i.v. contrast, 60 seconds delay to enhance normal three layers of bladder wall, sometimes whole abdomen post contrast.

Renal cysts
Scanning to determine whether simple or complex, looking for soft-tissue component indicating malignancy, illustrated by examples:
- Narrow collimation, 3–5 mm, pre and post i.v. contrast with delayed scan at 5 minutes.
- Measuring average Hounsfield numbers over an area – looking for enhancement post contrast.
- Polycystic kidneys – adults, **autosomal dominant inheritance**. Cysts also in pancreas and liver. BP raised, renal failure. Cysts may contain stones. Normal **renal architecture** may be destroyed.

Renal colic – CT v IVU (= intravenous pyelography, IVP); severe pain due to obstruction of urinary tract by stone:
- Quick, non-invasive, no i.v. contrast needed (contrast in IVU can hide small stone): stones show as small white densities.
- High sensitivity (95%–97%).
- Acute obstruction may lead to oedematous appearance of kidney.
- May demonstrate other pathology as well.
- But: increased radiation dose – 50% more – and does not demonstrate excretion.

Technique for renal colic
- Spiral acquisition on one breath-hold, 3 mm slice width, from top of kidneys to base of bladder, low mAs: 75–100.
- Prone position: differentiates bladder stones from vesico-ureteric junction (VUJ) stones.

Renal trauma – technique

- **Pre scan** from diaphragm to symphysis pubis (**CT KUB** = kidneys, ureters, and bladder).
- Repeat scan, 3 mm acquisition.
- 60 seconds post i.v. contrast.

Looking for serious injury such as avulsion (tearing away of blood vessels), bleeding, or leakage of urine: mild injury can be treated conservatively.
Acute bleed is denser (**hyperdense**), later becomes **isodense** and eventually **hypodense**. Proteinaceous material separates out and sinks in the abdomen.
Tamponade – pressure, e.g. from bleed in retroperitoneum, not present if intraperitoneal.

Renal CT angiography
Advantages:

- Quick, easy to perform, one i.v. injection.
- Multiplanar reconstructions.

Disadvantages:

- Resolution not as good as conventional angiography.
- Cannot perform interventional procedures.

Illustrated use in renal artery stenosis. Also used in proving normal anatomy of potential live kidney donor: not suitable unless blood supply is by a single renal artery.

Scanogram is a term for **whole-body scan** for planning purposes.
IVP/IVU: pyelogram is a picture of the collecting system, **urogram** is really of the cortex: these two terms have become interchangeable.

SUMMARY

- CT is an excellent modality for the renal tract.
- It has many clinical applications that complement other techniques.
- CT is gradually superseding IVU.
- Disadvantages: radiation dosage and use of i.v. contrast.

[Dr Brian Carter]

Lecture II: Iliac Artery Imaging and Interventions

Speaker: Dr Mark Thornton, Interventional Radiologist

Although interventional radiology (IR) has replaced a large part of conventional vascular surgery in today's hospitals, modern imaging technology allows surgeons to work in tandem with interventional radiologists to produce outcomes that strike a balance between medical and budgetary needs. Mark Thornton, an interventional radiologist at Southmead Hospital, explained how and why ultrasound, CT angiography, MR angiography and conventional catheter angiography – the four main modalities available in hospitals throughout the world – are used in the treatment of patients with vascular disease.

All four procedures have their advantages and disadvantages and Dr Thornton's presentation demonstrated that context is a key factor in determining whether and how they should be applied. The ideal imaging method, he explained, would be completely accurate, acceptable to patients, cost-effective, completely reproducible and readily interpretable.

In the real world, however, cost-effectiveness tends to be an overriding factor, and initial capital outlay is by no means always the defining criterion. For example, an MR (magnetic resonance) machine will cost a hospital in the region of £1 million but can be cost-effective as it can reliably predict whether a patient is suitable for treatment.

The four major imaging modalities

Ultrasound is the least expensive of the "big 4" modalities, with scanners costing from £10,000–£100,000. It also has the major advantage of being non-invasive (meaning that patients like it) and readily available insofar as the equipment simply needs to be plugged into a power socket. Moreover, it allows for evaluation of flow in real time and has a proven track record in follow-up and surveillance.

For all its advantages, ultrasound has a series of significant drawbacks. It is, for example, very operator-dependent and time-consuming (meaning that it is delegated to more junior staff). Furthermore, images are degraded in the presence of bowel gas, obesity or calcium. Sound travels best through liquid, explained Dr Thornton, and gas is a problem because sound waves bounce off it.

The quality of US examinations is also commonly devalued by inter- and intra-observer variability. Consequently, interpreting specialists are inclined to suspect that results might be wrong and therefore order further, confirmatory, imaging.

CT angiography is a more sophisticated and thus more expensive procedure. It has two major advantages for the patient, being non-invasive and not a completely closed tunnel. Surgeons, too, like CT as it produces angiogram-like, 3-dimensional images (unlike ultrasound): i.e. what they see on the image is what they will see on the operating table. In addition, patients who do not have palpable femoral pulses can have a CT angiogram. Furthermore, staff are not exposed to radiation since they are in a different room.

CT is also good at detecting calcifications, which is important because a lot of arterial disease becomes calcified in later stages. It tells surgeons whether they will be faced

with a soft tube, which they can cut and sew, or a rigid, calcified tube, which will not take sutures.

Weighing against these benefits are a series of disadvantages. CT scanners deliver a very high radiation dose, which is particularly relevant in young patients as it has implications for fertility and might induce fatal cancers (1:1000 chance). Furthermore, they require the use of contrast medium (CM), which carries its own risks.

CT also relies on good cardiac function. If a patient has a bad heart as well as bad circulation, images may be poor. Reconstructions (to make 3-dimensional models) are time-consuming and require expertise. If they are not performed properly, there is a danger of creating a picture that "may be beautiful, but is wrong", commented Dr Thornton.

If done properly, however, CT angiography is reliable enough for the surgeon to plan an operation. In the past, surgeons would often open the patient up in order to decide what to do, then decide to do nothing. This is extremely unusual now. The days of exploratory laparotomy are almost gone.

MR angiography (MRA) – a technique for studying the blood vessels using magnetic resonance imaging – similarly offers major benefits but also a number of drawbacks. MRA provides equivalent sensitivity to conventional angiography, but without exposure to radiation. As mentioned above, the equipment is expensive, but can be cost-effective nevertheless. It delivers angio-like images, which is what the surgeon wants.

Contra-indications are prominent among the disadvantages of this modality. MRA generates a high magnetic field, which is dangerous for some individuals (e.g. patients with pacemakers and those with ferromagnetic clips in their brain). As most patients Dr Thornton encounters are elderly and frail, many will have pacemakers or will have had neurosurgery. Metal implants of this kind will also produce "artefacts" (image distortion due to the presence of metal objects).

MRA is also more difficult to interpret than other modalities owing to the vast amounts of data that need to be manipulated in order to create a 3D image for the surgeon. Furthermore, the availability of this procedure is limited on account of its cost. It is therefore mainly reserved for neurology, then orthopaedic surgery, while other applications (such as IR) are frequently not considered eligible. This will change, however, as MR is proven to be a cost-effective way of obtaining a correct diagnosis. Last but not least, some patients do not like MR angiography as the machine is very claustrophobic, completely enclosed and very noisy.

The last of the "big 4" modalities is conventional, trans-catheter diagnostic **angiography**. This procedure has been in use for a very long time but still offers significant advantages. It is, however, invasive since it involves puncturing the artery, inserting a guide wire and placing a catheter. Although the devices have become progressively smaller and the risks less, there are still potential complications, meaning that the patient has to be consented. There is also potential for litigation, which does not happen with CT and MR.

Foremost among the **advantages** of angiography is the fact that it is easy to interpret and allows for immediate intervention (usually with a metal stent) – often as a day case. Furthermore, no sedation is needed. Angiography is also readily available: every big district general hospital in the NHS will have the requisite equipment and resources.

Angiography has a series of **disadvantages** aside from its invasiveness. It is very expensive (both the hardware and the fact that it involves an overnight stay). Like CT angiography, it uses contrast medium. Mortality due to intravenous contrast medium remains unchanged, at around 1:40,000, pointed out Dr Thornton. Conventional angiography also delivers a fairly big radiation dose (and there is some staff exposure). Finally, this technique does not provide 3D images.

Peripheral vascular disease (PVD) a huge problem

PVD is a huge problem, but it is largely unreported. One in five people over 75 have PVD to such an extent that they get **intermittent claudication** (IC). Derived from the Latin *claudicare*, meaning "to limp", IC is ischaemic pain in the leg muscles on walking.

Intermittent claudication is a relatively benign condition, which most people simply learn to live with and accept, said Dr Thornton, emphasising that its impact on an individual's quality of life depends on context (e.g. lifestyle, occupation, age, etc.). For example, the condition may not pose a significant problem to a person with a partner who can drive him/her around, but it will have a devastating impact on someone whose job entails a great deal of walking (a postman, for instance).

Only 15% of people with IC go on to develop **critical limb ischaemia** (CLI), which is characterised by rest pain, gangrene and ulceration. CLI patients are a very high-risk group, as 10% of people admitted to hospital with this condition do not survive to go home.

Treatments

Patients with CLI symptoms *have* to be treated, said Dr Thornton, and several endovascular treatments are available. The first-line therapy is "plain old" **balloon angioplasty** (POBA), a technique that has been around since the 1970s. If this does not work, a **stent** is implanted. ["Stent" is an eponym, having been named after Charles Stent, a Victorian dentist.] Modern-day stents are relatively expensive, costing around 10 times as much as a balloon catheter, but they last for about 10 years.

According to the BIAS (British Iliac Angioplasty Study) report, published in 2005 by the British Society for Interventional Radiology, IR interventions in intermittent claudication patients carry a 4% risk of complications, whereas the risk for CLI patients is 13%. Dr Thornton explained that the difference lies in systemic (as opposed to limb-related) complications. CLI surgery is, he noted, very high risk – especially as patients are usually elderly and frail. Interventional radiology has a very tiny risk of mortality compared to open surgery. It is therefore very safe, though the results are probably not quite as good.

Classification

Dr Thornton went on to discuss the classification of **iliac artery disease** according to TASC (the Trans-Atlantic Inter-Society Consensus working group, 2000), whereby lesions are grouped by type and length (classes A–D, in ascending order of

seriousness). POBA has a high initial technical success rate (approaching 100%) for TASC A lesions (stenosis less than 3cm) and 3-year patency rates of 75–95%.

Stenting is often employed as an alternative to an open bypass-type operation for TASC B lesions (a single stenosis 3–10cm or 2 stenoses < 5cm). Its use depends largely on the age of the patient. For example, a 40-year-old may benefit from an open operation, since this can last 30 years.

Studies show that surgery outcomes are significantly better than those of stenting, with primary patency rates after 1, 3, and 5 years for stenting being 85%, 72% and 64%, respectively, compared with 89%, 86% and 86% for surgery (Timaran CH, Prault TL, Stevens SL et al. *J Vasc Surg* 2003; **38**: 272–278). If you survive surgery, your outcome after 3–5 years will be better, but patients need to understand that there is a significant risk of a very adverse outcome from surgery. Most patients are at significant risk from vascular surgery and would generally be advised to try IR procedures first, said Dr Thornton.

Not surprisingly, the prognosis becomes progressively less favourable for the more severe, TASC C lesions and especially for class D lesions (patients with diffuse disease, i.e. arterial disease "from top to bottom"). Some of these patients (most likely smokers or individuals with a poor diet) are unreconstructable and "better left alone", Dr Thornton commented. The consensus view from the Trans-Atlantic group is that TASC D patients should always be offered surgery first. These patients do badly, however. "They are either fit enough for a big operation or for nothing." In these cases a staged approach is adopted, whereby IR is attempted, but the surgeon is on hand in case this does not work.

Looking to the future, Dr Thornton predicted a huge increase in severe arterial disease due to diet and lack of exercise.

[Neil Paget]

Lecture III: Screening for Cancer and Heart Disease using CT

Speaker: Dr Paul Coubrie, Consultant Radiologist

What is screening?

Screening can be defined as the identification of unrecognised disease in the apparently well. Women have to undergo a large number of routine screening procedures throughout their lives, while for men screening tends to be less frequent. The purpose is to identify disease for early treatment and, hopefully, complete cure.

Screening was first introduced to identify tuberculosis, the 'Great White Plague' of the 18th/19th centuries. In 1953 in Glasgow X-ray was used to screen for TB. In the 1940s/50s a TB vaccine became available and the number of deaths was significantly reduced. Screening has been seen as 'a good thing' for some time now, and in the UK teenagers are screened with the Mantoux test, which is important because 90% of TB cases are symptom-less. The disease is still very common in some places, e.g. India.

Mammograms for breast cancer are an unpleasant form of screening but they do save lives. The neonatal heel prick is a common test for congenital diseases. It is now usual for GPs to screen routinely for heart disease by measuring patients' blood pressure. In smokers/diabetics the cholesterol level is also measured.

The Wilson criteria for screening (derived from a World Health Organization monograph by Wilson and Jungner, published in 1968) emphasise the important features of any screening programme, as follows (see www.gpnotebook.co.uk):

- The condition should be an important health problem.
- The natural history of the condition should be understood.
- There should be a recognisable latent or early symptomatic stage.
- There should be a test that is easy to perform and interpret, acceptable, accurate, reliable, sensitive and specific.
- There should be an accepted treatment recognised for the disease.
- Treatment should be more effective if started early.
- There should be a policy on who should be treated.
- Diagnosis and treatment should be cost-effective.
- Case-finding should be a continuous process.

What is CT?

CT stands for computed tomography. This procedure is based on X-rays. The X-ray tube generates X-rays from electricity. A shadow is cast depending on thickness and density. In tomography, imaging takes place by sections, i.e. the X-ray tube is moving. To interpret the results it is possible to plot a matrix of density values. By knowing the amount of X-rays coming in on each side of the matrix, the density in each box can then be worked out.

An electrical company called EMI designed the first CT/brain scanner. The first clinical trials took place in 1971 in London. This constituted a real breakthrough. The old CT scanner used to rotate round the patient, who would then be moved a little further along and so on. It took one minute per slice, 20 seconds to rotate and 40 seconds to reconstruct the picture. Now the volume of data is absorbed in a spiral and

the slices are then reconstructed in a matrix. CT scans of the chest now comprise 250 images, which illustrates the huge progress that has been made.

[At this point, a member of the audience asked whether there was any difference between a CAT scan and CT scan. Dr. Coubrie answered that the two terms are interchangeable and computerised axial tomography is also used.]

Colorectal cancer (bowel cancer) screening

Bowel cancer is the second most common form of cancer after lung cancer. Many prominent people (e.g. Malcolm Marshall, Audrey Hepburn, Sharon Osbourne) have suffered from this common disease and yet it is mentioned only very rarely. The annual death toll from it amounts to almost 20,000. One in 20 UK residents contract the disease and half of these people die as a result.

Cancers of the bowel and colon are fairly similar in nature but are to be distinguished from anal cancer, which is more like a form of skin cancer.

The adenoma-carcinoma sequence takes the following course: at the start, some small polyps form in the bowel. These are probably benign. However, over a number of years they can slowly turn dysplastic, i.e. they develop pre-cancerous abnormalities, and eventually become a malignant form of cancer. 90% of cancers go through this type of change.

Thirty percent of people over the age of 60 have some polyps. But there is only cause for concern if these polyps are larger than 6 mm; if they are smaller than this there is a negligible likelihood that they will become cancerous.

In screening, we therefore need to look for such polyps. This is done by endoscopy, i.e. using a camera on a flexible tube passed through the anus, and for the large colon this procedure is called a colonoscopy. The aim is to catch the polyps early while they are still confined to the bowel wall. Unfortunately, large bowel tests are less than popular with patients…

Screening is scientifically accepted. In some places, pre-screening faecal occult blood (FOB) tests are now performed; if the test is positive (without having been influenced by ingestion of particular foods, e.g. black pudding), it is then followed up by more in-depth screening. This practice has led to a 60% drop in mortality.

Another fairly accurate but widely disliked test is the barium enema. Its most unpleasant feature is the fact that patients have to ingest potent laxatives for 2 days before the actual enema. Although a colonoscopy is actually worse than a barium enema it is not usually perceived that way since patients get sedated for colonoscopies but not for barium enemas! For one in 500 patients colonoscopy may induce a bowel perforation accompanied by a significant bleed whereas for the barium enema this figure is as low as one in 100,000.

Forms of CT colonography are CT pneumocolon and virtual colonoscopy (VC). These very accurate methods of detecting polyps are more popular because no strong laxatives are needed. The result can be reconstructed into 3D models. The procedure takes 20 minutes and no sedation is necessary. It is a good test, the only drawback being that no biopsy is possible. In the UK CT colonography is now becoming more routine. However, the images need to be interpreted by experienced staff.

Lung cancer screening

The next slide showed a number of prominent lung cancer sufferers (e.g. Alistair Cooke, Walt Disney, Nat King Cole, Yul Brynner), all of whom succumbed to the disease, some of them still quite young. By the time people present with symptoms of lung cancer two thirds are incurable. Eighty percent of these are dead within one year. Median survival is 6 months. These survival rates have remained unchanged for the last 30 years. Lung cancer is the top killer among all forms of cancer.

Ninety percent of sufferers contract the disease through active or passive smoking. It is very common in ex-smokers. If the disease is caught in stage one, i.e. when its spread amounts to less than 2 cm, the chance of survival is just under 50%.

Three trials (albeit not randomised controlled trials) were carried out in the 1970s looking at chest X-rays. Sputum cytology led to a higher detection rate but no change in mortality. Chest X-rays proved to be worse than flipping a coin for early detection. As a result, chest X-rays and sputum cytology were abandoned.

Modern-day CT resolution is less than 1mm, thus offering greater sensitivity for detecting lung cancer than any other modality, but unfortunately there are insufficient resources to screen everybody. If the cancer is detected in stage one and excised, the patient's chance of surviving the next 5 years is as good as anyone else's, i.e. 85% or higher. Conversely, in one trial where 45 stage one cancers were detected in people who refused surgery, only 2 of those patients were still alive after 5 years.

When examining whether mortality is changed by screening it is important to take lead time bias into account. In this context a couple of definitions will be helpful:

Lead time: This is the period between early detection of disease and the time of its usual clinical presentation.

Lead time bias: When evaluating the effectiveness of the early detection and treatment of a condition, the lead time must be subtracted from the overall survival time of screened patients to avoid lead time bias. Otherwise early detection merely increases the duration of the patients' awareness of their disease without reducing their mortality or morbidity. Numerous cancer screening procedures were thought to improve survival until lead time bias was addressed. (See www.gpnotebook.co.uk.)

While there are conflicting results as to whether mortality really is changed by screening, the results from a number of randomised trials currently in progress are awaited within the next 10 years. Some forms of lung cancer and bowel cancer grow very slowly, and synchronous cancers occur in one out of 50 cases.

A neurosurgeon has coined the acronym VOMIT: Victims of Medical Imaging Technology. Because CT is so sensitive at picking up tiny abnormalities, we don't know whether these are the start of something serious, a variation of the normal or just one of those things that comes and goes and we don't need to do anything. The patient may need more tests, surgery or repeat scans over a number of years to make sure the abnormality doesn't grow. On average £150 per patient is spent on following up these abnormalities outside the colon. It can be argued that some of this follow-up isn't necessary but serious diseases have been identified this way.

The results of CT are not always brilliant or specific enough, as demonstrated by the case of a 60-year-old woman who had an enlarged uterus. In 98 cases out of 100 this is due to fibroids but here it turned out to be an advanced cancer of the uterus.

Coronary calcium scoring

Cardiovascular disease kills many more people than cancer. Of the 216,000 CVD-related deaths each year, 30% are due to stroke and 50% to heart disease. Many of these patients show symptoms for years before death and treatment for these symptoms costs the NHS £16 billion annually.

Arteriosclerosis, a hardening of the arteries also known as atheroma, is a form of endothelial damage, i.e. the lining of the artery is damaged. As this situation deteriorates, calcium deposits narrow the artery, leading to angina, a pain that is felt during exercise. In its moderate phase, angina is reversible with aggressive treatment.

The risk factors for coronary heart disease are as follows: LDL (low-density lipoprotein) cholesterol, high blood pressure, being a smoker, age, male gender, and diabetes. A population study at Framingham, Massachusetts, has shown that the disease is only 60% predictable by risk factors. 50–60% of CHD sufferers die suddenly or from a heart attack or hidden atheroma.

Functional tests for the detection of hidden atheroma (= a fatty deposit in the intima (inner lining) of an artery, resulting from arteriosclerosis [www.medterms.com]): include stress echocardiography, exercise ECG, and nuclear medicine perfusion scanning. Imaging tests include catheter angiography, CT coronary angiography and intravascular ultrasound. The hardening of arteries, usually caused by calcium deposits, has been known as a risk factor for heart disease since 1700. This phenomenon can be detected on X-rays.

By the 1980s, CT scanners were so far advanced that it became possible to look into the heart. The furring that can be seen constitutes the amount of calcium build-up. Dr Arthur Agatston (creator of the South Beach Diet) devised the coronary artery calcium (CAC) score: while not a diagnostic test *per se*, the CAC score has proved useful for prognosis, i.e. it indicates the likelihood of having heart disease.

The following table lists a number of factors that increase the risk of CHD by comparison with the general population:

Factor	Risk increase
Smokers of 1 packet of cigarettes per day	2.5-fold
Elevated cholesterol	2.5-fold
Systolic blood pressure >150 mmHg	2-fold
Sedentary lifestyle	2-fold
CAC score >100	25-fold

The CAC score is therefore a good predictor of possible CHD. It is particularly useful in patients in the intermediate risk category (e.g. older than 40 years and perhaps ex-smokers or people with high blood pressure) or who present with atypical chest pain. If the CAC score for such patients is zero (which means a 98% chance that their heart will stay well for the next 5 years), the possibility of heart disease can be ruled out.

Patients with a calcium score <100 are doing something right and should be encouraged to keep it up. Those with a score >100 may be able to reduce their risk by taking aspirin and/or a statin to lower their cholesterol. And those with a score >400

are in need of aggressive risk factor management and may benefit from a functional assessment.

In this context, electron beam computed tomography (EBCT) can be used to detect calcium build-up in the lining of arteries. An EBCT scan is much faster than a standard CT scan: it can make an image in a fraction of a second and can take a clear picture of an artery even while the heart is beating. However, this expensive type of CT is unlikely to be around for much longer since modern multi-slice CTs have now caught up with it.

Controversies surrounding screening

An NHS breast screening programme was started in the UK in 1986. More than 1.5 million screening procedures are carried out annually. The recall rate is 5% and 6000 cancers/year are detected. Until 3 years ago there was no scientific evidence that screening does save lives; however, the number of deaths has gone down by 21% since inception of the programme although only 6% of this improvement is due to screening. The reason for this is that breast cancer treatment services have improved as a whole and so have awareness, self-testing, diagnosis, pathology, surgery, chemo- and radiotherapy. All these services have improved because screening was started. However, optimum strategies are still being devised. There is, for example, discussion about having 2 rather than just the one mammogram at the same time. Trials for ovarian, prostate and lung cancer are also in progress.

However, a significant problem remains with lung cancer: only 3% of research funds are allocated to lung cancer while 17% go to leukaemia although the former is a much more serious issue. The public perception/image of the two diseases appears to be the overriding factor here rather than allocation of funds based on the scale of the respective disease entities.

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