

Minimising the impact of errors in the interpretation of Computed Tomography scans for surveillance and evaluation of therapy in Cancer.

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**Abstract**

Radiological error is inevitable and usually multifactorial. Error can be secondary to radiologist specific causes, including cognitive and perceptive errors or ambiguity of report, or system related causes, including inadequate, misleading or incorrect clinical information, poor imaging technique, excessive workload and poor working conditions. In this paper, we discuss a systematic approach to reduce errors in oncological radiology reporting, thus reducing risk to the patient. Rather than attempt to discuss all types of error we concentrate on the most important and commonly occurring errors that we have encountered over 20 years of practice, based on a weekly discrepancy reviews of our practice and independent reviews of clinical and research imaging from other institutions. This review focuses on CT scan reporting for staging, surveillance and response assessment of cancer patients, but the messages apply to all imaging modalities.

## **Introduction**

Mistakes in the interpretation of medical images are common and probably inevitable<sup>1</sup>. Their frequency reflects a huge expansion of medical imaging, increasing demands on radiologists and the increased complexity of scans<sup>2,3</sup>. Of all medical errors, imaging errors are often more apparent due to the ease of recalling images. Furthermore, imaging errors in oncology will grow over time. Many strategies have been devised to reduce reporting errors, but unfortunately the best strategy appears to be double reporting, which is beyond the resources of most departments<sup>4</sup>.

Errors fall into similar patterns<sup>3,5</sup> and oncology imaging is no exception. In this paper, we aim to discuss the most common and clinically important CT reporting errors<sup>6</sup>. These have been identified through 20 years of experience at weekly discrepancy review meetings in a cancer centre, managing clinical trials and providing independent imaging reviews for other hospitals and outside agencies, such as the European Organisation for Research and Treatment of Cancer (EORTC) and Cancer Research UK (CRUK).

This article is organised into headings to emphasise the importance of context. For example, missing a small lung metastasis in a case of advanced cancer is probably of little importance, whereas spotting incipient spinal cord compression may spare the patient paralysis in their final months. Conversely, missing numerous metastases in a asymptomatic surveillance case may be embarrassing, but have little clinical impact, as treatment would probably be palliative; however, missing a solitary small metastasis or incidental primary tumour could deprive the patient of potential “life-saving” treatment.

### **Failing to spot new cancer (staging or surveillance failure)**

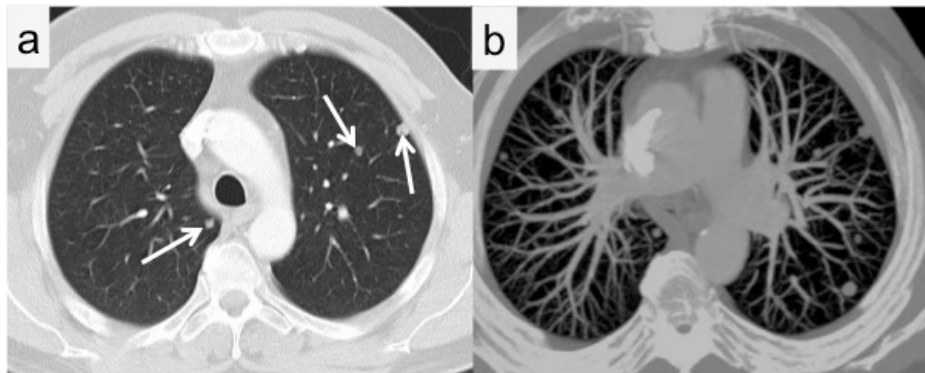
The aim of surveillance (or screening) is to identify disease early to improve the chance of cure. Like screening programs, surveillance programs work if they can identify disease early enough to deliver a treatment and therefore survival advantage. It is not the aggressive, untreatable recurrence that we are interested in, but the isolated surgically resectable liver metastasis or even the incidental curable early lung or renal tumour. Spotting an early lung metastasis may also spare the patient unnecessary debilitating radical surgery. We recognise these issues can occur anywhere, but give 5 rules to avoid most mistakes:

1: Adjust Window Levels and Centres<sup>7</sup>: In the days of “hard copy” printed film, a culture developed of soft tissue and lung windows to view CT. Printing multiple windows was generally not considered cost-effective<sup>8</sup>. Viewing “bone windows” required queuing up to use the workstation and could not be done for imported films. However, it is surprising in the modern PACS era that we still see reporters relying on a single soft tissue window to review the whole body viscera. There is good evidence that changing windows in oncology scans is useful<sup>9,10</sup> and at a minimum the body should be reviewed using 5 window settings: soft tissue, lung, bone, liver and vascular<sup>11</sup>. The actual window level and width used will vary depending on slice thickness, exposure factors and presence of contrast media.

2: Review the lungs using Maximum Intensity Projections (MIPs): These MIPs are created using thick slices with small inter-slice increments e.g. 8 mm on 1 mm increments. This approach is as old as spiral CT itself<sup>12</sup> but keeps needing to be

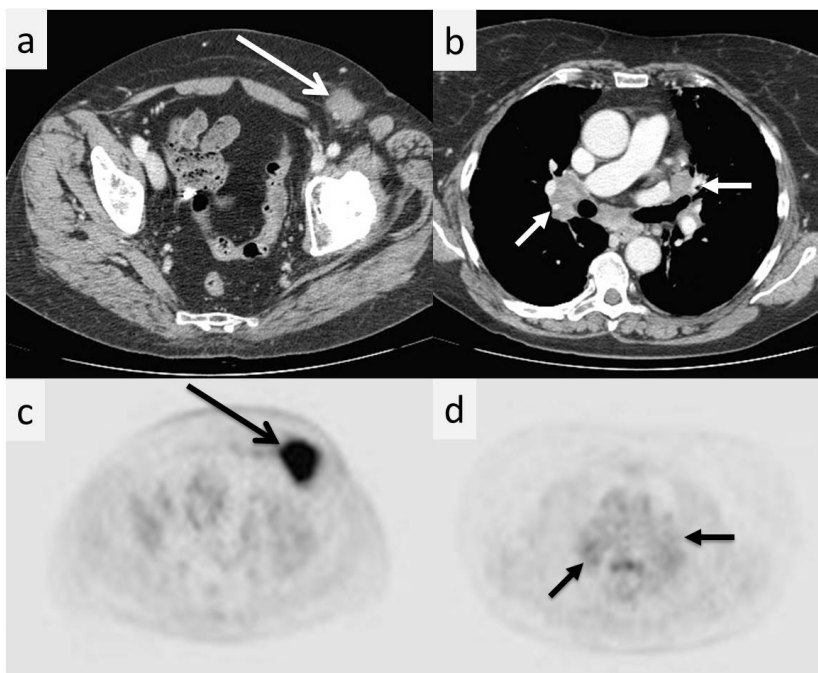
re-advertised<sup>13</sup>. This is a dynamic process where scrolling through the images emphasises the tubular nature of vessels thereby making nodules stand out, greatly increasing the visibility of lung nodules (figure 1). There are very few cases with multiple lung lesions where the reviewer will not find more using this technique. Detecting more lung lesions will result in increased false positives<sup>14</sup>, but we think this is a decision to take after spotting lesions, not one to avoid by deliberately ignoring them. Our advice is the reporter should have a good reason not to do this in any case.

*Figure 1: Maximum intensity projections for Lung. Standard lung CT slice (a) with small lung metastases shown by arrows, compared with (b) a maximum intensity projection of lung tissue reconstructed to thick slices with thin inter-slice increments. This is normally a dynamic process, but this very thick slice MIP demonstrates the principle by emphasising the tubular nature of vessels and therefore increasing the conspicuity of nodules.*



**3: Focus surveillance first on lesions that are curable:** There is no point labouring to pick up possible metastases at the expense of missing the small incidental metachronous lung, renal, breast or colon tumour. Furthermore, finding a subtle irrelevant lesion may lead to missing an important one, the so-called “satisfaction of search”<sup>15,16</sup>.

**4: Avoid false positives, not all disease is cancer, even on surveillance:** Most patients with a significant cancer history and new symptoms will show progression, but the radiologist must always be open to an alternative non-malignant diagnosis (figure 2).



*Figure 2: Benign disease mimicking malignancy: 65 yr female with Hodgkin's Lymphoma in the left groin (a), avid on 18-FDG PET scan (c), and mediastinal and hilar lymphadenopathy (b), which was not 18-FDG avid (d) and subsequently diagnosed as sarcoidosis.*

Care should be taken in the interpretation of incidental pulmonary nodules, as many will turn out to be benign<sup>14</sup>. False positives are generally unrepresented in discrepancy reviews and may be perceived as less important<sup>5</sup>. However, they do consume resources and lead to unnecessary investigation, intervention and worry. This is particularly recognised in breast cancer screening<sup>17</sup> and training efforts have been made to reduce this<sup>18</sup>.

5: Avoid repeating the same mistake (alliterative bias)<sup>19,20</sup>: Patients on surveillance may have repeated CT scans and hopefully these will remain normal. However, when a small abnormality appears it may be missed. This mistake may be repeated if it is a “blind spot” for that particular radiologist and they report subsequent scans. A good example of a “blind spot” is an intramuscular metastasis. As for lesions in the corner of a film, if you do not look for them, you shall not see them! Our team has an agreement that once a specific radiologist has reported 2 consecutive surveillance scans for a patient; the next will be reported or at least reviewed by another radiologist.

### **Failing to spot complications of cancer– “palliative sweep”**

For patients with advanced cancer on treatment, failing to detect a small site of new disease is unlikely to have a strong deleterious effect to the patient, unless there is a clear alternative treatment. However, the radiologist does have one very important task in these patients: the “palliative sweep”. Advanced cancer patients have a high chance of developing complications that can be successfully ameliorated, improving their quality of life. Many of these problems, such as bowel or bile duct obstruction may be apparent clinically, but the radiologist ideally will detect these problems early to instigate palliative treatment. We suggest a further five rules.

1: Multi-planar Reconstructions (MPR) are crucial: Cancer complications are often better appreciated in different scan reconstruction planes. Sagittal MPR has been shown to improve the detection and assessment of spinal trauma and other lesions<sup>21,22</sup>.

Reviewing the spine in all 3 planes is likely to increase the number of lesions detected (figure 3).

*Figure 3: Multi-plane reconstructions: Axial CT slice through the L1 vertebra (a) in a 73 yr with previous bowel cancer and presenting with weight loss. Although this scan shows the vertebra is abnormal with sclerosis and irregularity, the abnormality is much more conspicuous on the sagittal reconstruction (b) The sternal metastatic deposit is clearly seen on the sagittal reconstruction. This principle also applies to coronal sections for the hips etc..*



2: MPR is not just for spines: All sub-specialities will have their preferred multi-plane and 3D reconstructions for the primary assessment of different cancers. The general oncologist should bear this in mind and develop their own standard, which may include using the coronal plane to assess the mesentery and GI tract, hips and pulmonary vasculature<sup>23</sup>. Similar to using different window settings, this approach previously had a significant time penalty, both in image processing and reporting<sup>24</sup>. However in the multi-detector CT era, it has been suggested that using MPRs can actually speed up the process and reduce the need for contrast enhancement in some circumstances<sup>25,26</sup>.

3: New symptoms and signs may not be communicated to the radiologist: A key problem in identifying complications of cancer is when surveillance scans are booked weeks or months in advance. This is a useful process to plan CT scan appointments for patients on cancer pathways or clinical research trials, but it has the disadvantage that new symptoms may not be communicated to the radiologist (figure 4). It is useful to have a system where the scanning radiographers can alert the radiologists to any additional complaints the patient may mention at their appointment.



*Figure 4: Inadequate clinical details: Axial CT scan image through the upper thorax. This cancer patient had a pre-planned CT appointment for surveillance with no new symptoms declared. The scan was reported as clear with no new abnormalities identified. The oncologist asked for review when the patient declared new neck and arm pain and altered sensation in clinic. Epidural spinal recurrence (arrows) was diagnosed immediately on review of the images, confirmed by MRI and treated with radiotherapy.*

4: Focus on treatable problems – “spine, hips and tubes”: Most radiologists will do a final review of a scan and possibly the scout views<sup>27</sup> to make sure they have not missed something incidental. Quality of life may be adversely affected by 3 key complications: expansion in an enclosed space (brain or spinal cord), catastrophic bony fracture (spine, pelvis or femur) or blockage of a crucial tube (airway, blood vessel, ureter or bile duct). All these can benefit from palliative therapies.

5: Pick up the phone: Make sure all unexpected findings are adequately communicated. An electronic reporting system is no longer good enough in modern busy hospitals. “The single biggest problem in communication is the illusion it has taken place” attrib. George Bernard Shaw<sup>28</sup>.

## **Failing to spot complications of treatment – “Hippocratic failure”**

The Hippocratic oath declares: “above all, do no harm”, but unfortunately cancer treatment is often radical and life threatening. The radiologist needs to be aware of potential complications arising from the patient's medical or surgical therapy. Complications of radical surgery, radiotherapy, bone marrow suppressing chemotherapy and new biological and immune therapies are innumerable and ever changing. Radiologists are well aware of neutropenic sepsis, neutropenic (or immune related) enterocolitis (typhlitis) and many other complications, but there are two important recurring themes.

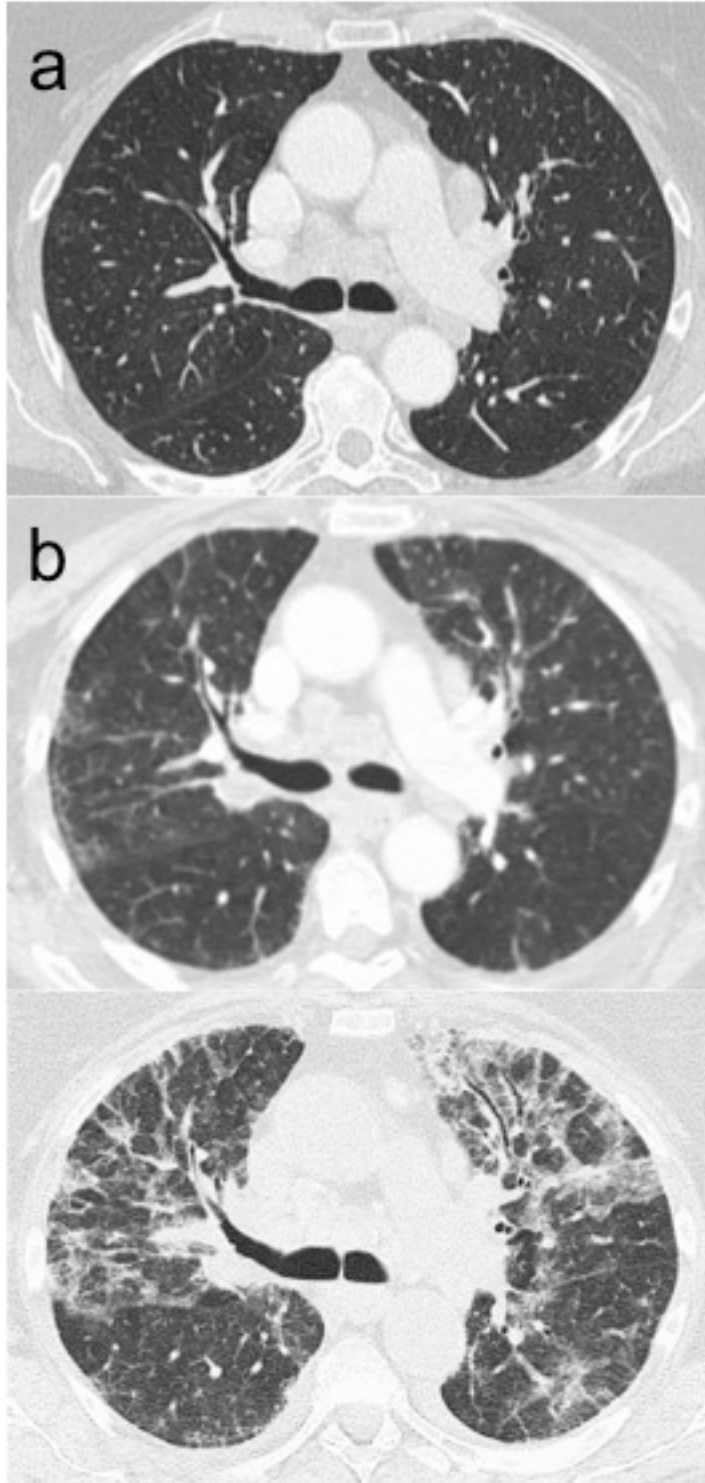
1: Pulmonary Embolism: Venous thromboembolism (VTE) is common in all cancer patients<sup>29</sup>, with pancreas, stomach, and lung cancer appearing to be the most common cancer types<sup>34</sup>. Chemotherapy and modern biological therapies are also independent risk factors<sup>32,33</sup>. Most patients with unsuspected pulmonary embolism (PE) on staging CT scans are actually symptomatic on detailed questioning, suggesting their PE is clinically significant<sup>30</sup>. A consensus statement recommends that incidental VTE be treated the same as symptomatic VTE, but that care should be taken with peripheral sub-segmental PE, especially if breathing artefact is possible<sup>31</sup>. Detection is theoretically hindered when using “standard” delayed-phase contrast imaging through the chest rather than dedicated CT pulmonary angiograms<sup>40</sup>. However, in the authors’ opinion, non-ideal protocols on modern MDCT have higher diagnostic accuracy than the CT pulmonary angiograms performed on early single slice spiral CT scanners. Therefore, on all contrast enhanced CT scans the pulmonary arterial tree should always be reconstructed at a suitable slice thickness and the lung vasculature systematically reviewed to detect PE<sup>41</sup>.

2: Therapy induced lung damage: Drug-induced interstitial lung disease (DILD) can be caused by chemotherapeutic agents through a variety of mechanisms<sup>42</sup> causing interstitial inflammation, fibrosis, bronchospasm, pulmonary oedema, and pleural effusion<sup>43</sup>. Bleomycin, gemcitabine and methotrexate are well documented to cause lung injury, but bleomycin may be the most devastating as it tends to be used in curable cancers (e.g. Hodgkin’s lymphoma and testicular seminoma) and may progress rapidly, even after stopping treatment<sup>43</sup> (figure 5). However, the radiologist should be aware that newer agents are constantly being developed that can cause lung damage, such as Everolimus<sup>44</sup> and that lung injury has even been documented with tamoxifen<sup>45</sup>. Co-administration may increase toxicity and the combination of gemcitabine and bleomycin can be very toxic<sup>46</sup>. DILD may be dose and dose-rate dependent<sup>47</sup>, or idiosyncratic, occurring even at low doses<sup>48</sup>. Radiation therapy is also responsible for lung injury, with total body irradiation for allogeneic bone marrow transplantation having an incidence of interstitial pneumonitis of 20%<sup>51</sup>. Radiotherapy also increases chemotherapy related lung damage<sup>52</sup>.

Lung injury findings are non-specific with considerable overlap, with variable clinical and imaging presentation<sup>53</sup>. The CT scan may be the first clue to a problem and new lung changes MUST always be treated with suspicion and rapid communication to the clinical teams. “Dependent lung changes at the bases” is a common radiological report in the elderly, but great care should be taken with this finding in chemotherapy patients, especially the young.



*Figure 5: Drug induced lung disease: CT scan images of a 67-year old female with Hodgkin's Lymphoma pre (a), 8 weeks (b) and 12 weeks post ABVD treatment. Treatment was stopped and steroids initiated at 8 weeks after cough developed and (mild) early lung changes were identified, but interstitial lung changes typical of Bleomycin toxicity continued to progress. This patient survived, but with impaired lung function. However, delay in diagnosis can be fatal.*



## **Failing to recognise limitations of anatomical imaging**

CT shows morphology and uses electron-density to contrast different soft tissues, which may be altered by contrast enhancement. As such it has two major weaknesses for oncology imaging; first, not all tumours have different electron-density or contrast enhancement compared with the surrounding tissues and second, the magnitude or speed of change in tumour size on treatment does not always correlate well with clinical outcome. Dealing with both of these issues requires a well-trained and experienced radiologist, but there are a few key pointers to avoid common pitfalls in both pre-treatment scans and follow up of therapy.

1: Some tumours are difficult to see: Whilst primary lung cancer and metastases can be amongst the easiest tumours to define, lending themselves to computer based measurement software, sometimes lung cancer can be masked by surrounding consolidation and atelectasis. Thus, the 'apparent' tumour can actually shrink on antibiotics alone. Different contrast-enhancement protocols will have different benefits; arterial phase being helpful in the mediastinum, but delayed phase often showing better tumour delineation from surrounding collapsed lung. We therefore avoid early-phase contrast imaging for lung and pleural tumours on follow-up. Pancreatic tumours may also be difficult to define and may have variable enhancement due to varying amounts of desmoplastic stroma in the primary tumour. This means that their metastases may look different, give better cell return on biopsy<sup>55</sup> and behave differently on treatment. Ultimately multiphase imaging is generally the best way to truly define these tumours when small.

2: Know what is expected: A 30% reduction would be a positive outcome for 2<sup>nd</sup> line therapy for carcinoma of the lung, but a complete response is expected in first line therapy for lymphoma. The radiologist must understand the significance of residual disease and communicate this clearly, as it may require a change of treatment strategy.

3: Size isn't everything: Radiologists are becoming much more aware of the effect of treatment on tumour enhancement, especially with new cancer therapies. Failing to appreciate necrosis can lead to two distinct errors. Firstly if a tumour is occult pre-treatment then treatment necrosis can make it visible, and therefore appear as an enlarging lesion. We have seen this most commonly in the liver metastases, particularly from breast cancer (figure 6).

Secondly, a reduction in enhancement or necrosis may be a good sign of tumour response even if there is little or no size reduction; this should not be missed if the tumour does not shrink (figure 7)<sup>56,57</sup>.



Figure 6: Changes in enhancement mimicking progression: CT liver images pre (a & c), 8 weeks (b) and 24 weeks (d) post chemotherapy for metastatic breast cancer. The 8-week scan was initially interpreted as progressive disease as the metastases appeared more prominent, due to necrosis secondary to treatment. On review this was changed to “partial response” by using liver windows (c) at baseline, showing the lesions were bigger than previously recognised (dashed white line). This was confirmed by complete response by week 24 (d). A further clue was to appreciate the change in the liver surface on both 8 and 24 weeks (solid white line).

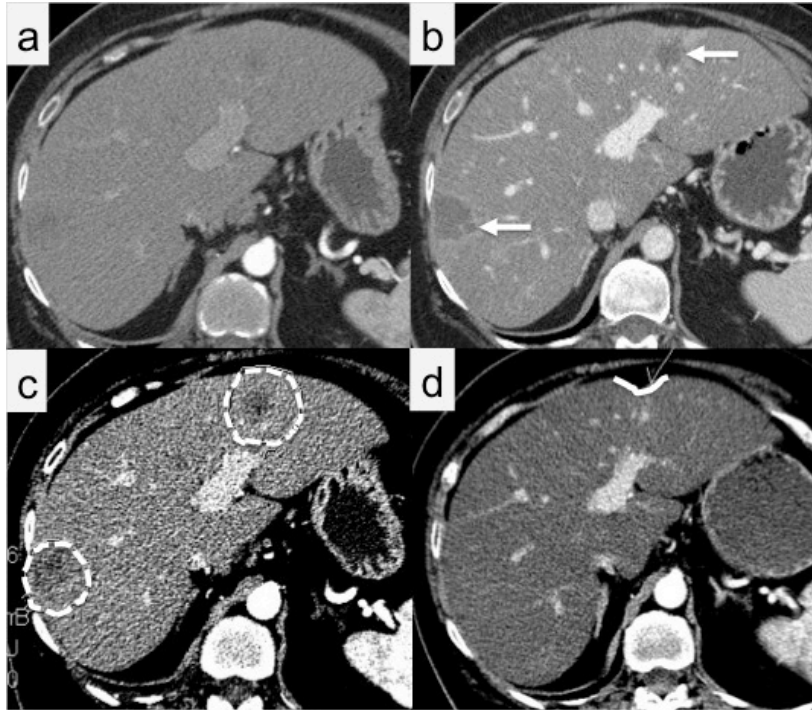
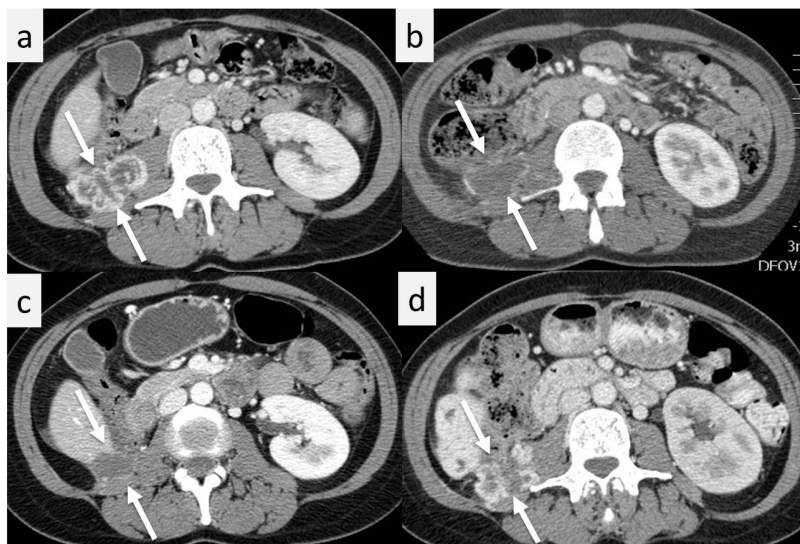


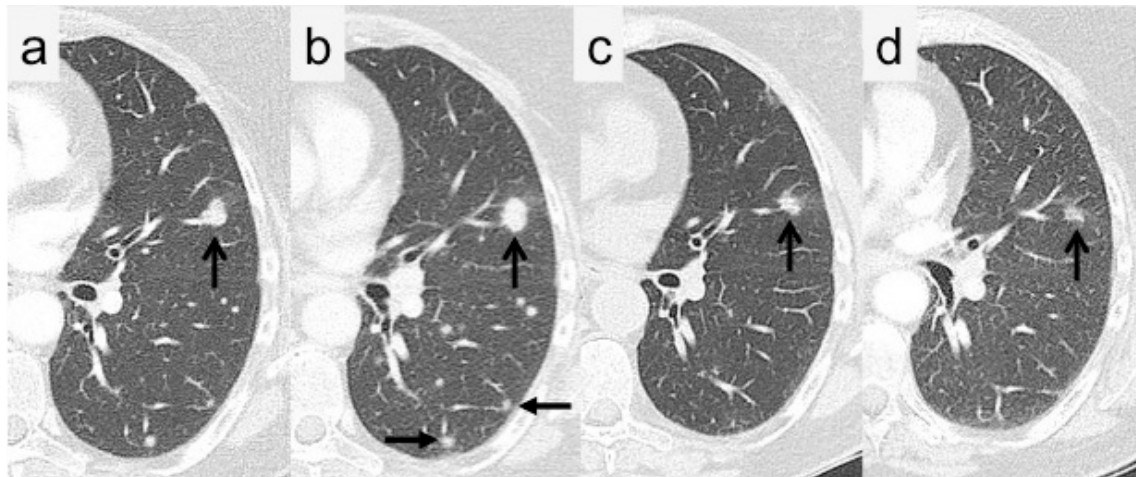
Figure 7: Necrosis on successful therapy: Axial CT images of a patient metastatic renal cancer pre-treatment (a) and 12 weeks (b) 1 year (c) and 2 years (d) post treatment with the anti-VEGF angiogenesis inhibitor Sunitinib. The 12-week scan showed little size change in lesion size (white arrows) but considerable reduction in enhancement. Subsequent scans showed size reduction as well as maintained reduction in enhancement. Widespread Progression at 2 years was accompanied by return of enhancement.



4: Pseudo-progression: Things can appear to get worse before they get better. It has long been established that tumours can initially increase in size during radiotherapy due to inflammation. This is an indication of treatment effect and is particularly seen in Glioblastoma after radiotherapy and chemotherapy. Likewise, rebound thymic hyperplasia in those recovering from a stress event, such as cancer therapy or complication, should not be misinterpreted as mediastinal recurrence.

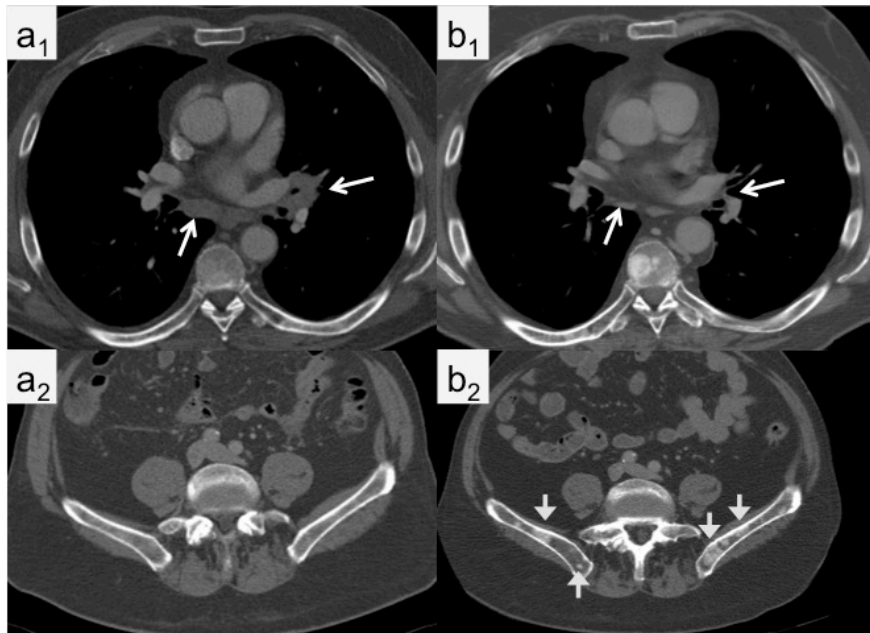
More recently, the development of immunotherapy has made pseudo-progression more common <sup>58</sup> (figure 8). Immunotherapy is a good example of why the oncology radiologist needs to keep abreast of new treatments, which have different complications (immune-related adverse events) and patterns of disease response. Immunotherapy now has its own adapted reporting criteria for clinical research trials <sup>59</sup>.

*Figure 8: Pseudo-progression: Axial CT images of the lung of a patient on immunotherapy (PD-1 inhibitor) for metastatic lung cancer, pre-treatment (a) and 6 weeks (b), 10 weeks (c), and 1 year (d) post treatment. The lesions initially enlarge (open arrows) before maintaining a partial response. Other lesions were also shown to become less distinct on the 6-week scan (closed arrows).*



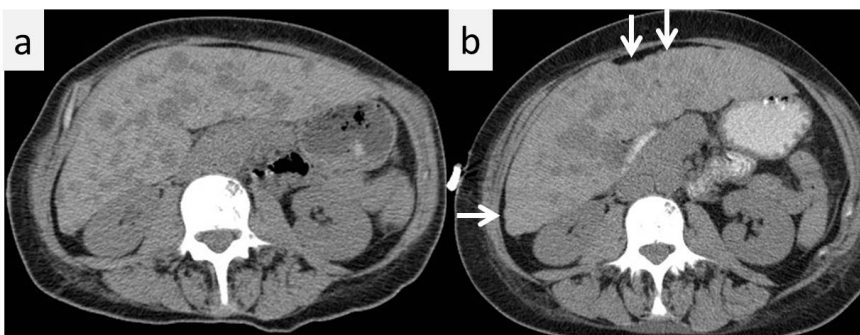
Another similar cause of this phenomenon occurs in bone - the “flare” reaction. In this scenario occult bone metastases suddenly become visible due to sclerosis on treatment. We see this primarily in breast cancer (figure 9) but would consider the diagnosis in any cancer. The key thing about all these “pseudo-progressions” is that they tend to occur early in therapy, and this diagnosis should always be considered if new findings are seen on the first post-treatment scan. However, tumour size increase on later scans, especially after response, generally indicates true progression.

Figure 9: Flare reaction: Axial CT images performed pre (a) and post (b) chemotherapy for metastatic breast cancer. The hilar and mediastinal lymphadenopathy resolved (a1 and b1, white arrows), but the newly apparent bone lesions in the pelvis (b2, black arrow heads) caused a non-specialist radiologist concern. These were re-reported on review as good sclerotic response (flare reaction) in previously occult bone metastases.



Another common sign, seen mainly but not exclusively in breast cancer, is pseudo cirrhosis of the liver due to rapid reduction in extensive liver metastases (figure 10)<sup>60</sup>.

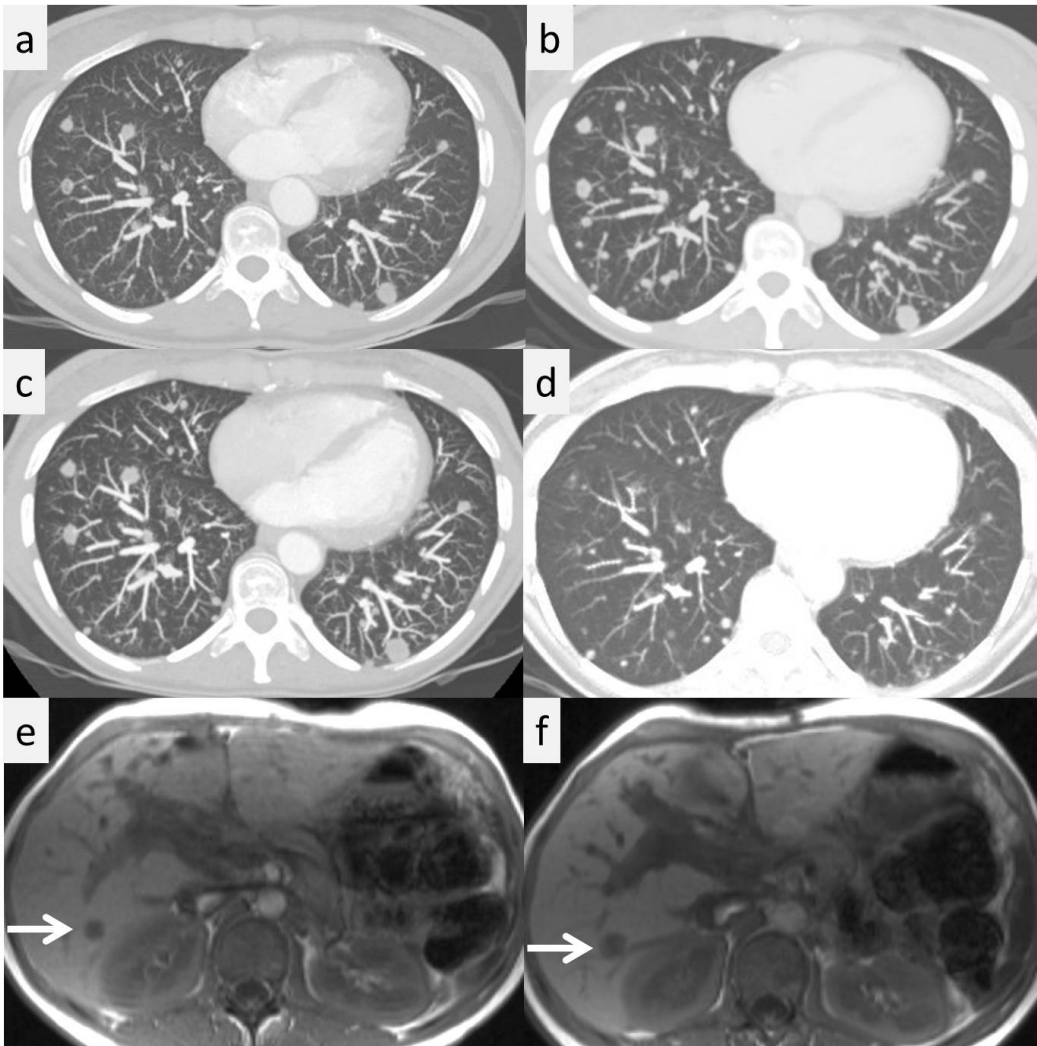
Figure 10: Pseudo cirrhosis: CT scans pre (a) and post (b) chemotherapy for extensive liver metastases from breast cancer. This shows irregularity of the surface of the liver due to shrinking of the liver metastases (arrows). Where baseline disease is widespread and treatment effective this effect can be dramatic, giving the impression of a cirrhotic liver.



**5: “Pseudo-pseudo-progression”:** This is our new term for an incorrect assumption of disease progression on treatment, due to a mismatch between scan timings and actual treatment dates. This can happen in 2 ways; firstly by having a long period between the pre-treatment scan and treatment onset and secondly, by the radiologist not appreciating the treatment dates, possibly due to limited information on the imaging referral forms (figure 11). In clinical trials of cancer therapy, as much as 42 days can be allowed between the pre-treatment scan and initiation of treatment. In clinical practice, for the patient’s convenience or resource reasons, this may stretch to as long as 8 weeks.

However, in patients who have undergone repeat scans before treatment we have seen tumour progression in as little as 2 weeks in a variety of cancer types, as defined by RECIST 1.1 criteria<sup>61</sup>. Therefore, when identifying tumour size increase in the first post-treatment scan, particularly if this is only after a short interval of treatment, consider whether any progression seen actually occurred pre-treatment. If available, review of radiotherapy planning scans may provide a useful interim time-point.

*Figure 11: Patient 1 (a-d) is a CT scan series in a 48yr female pancreatic cancer patient with lung metastases. Scan (a) is the staging scan with (b) 6 weeks (c) 9 weeks and (d) 5 months after. Scan (c) was performed after an episode of shortness of breath and was interpreted by the on-call radiologist as progressive disease on treatment compared with scan (a). On review, this was changed to “stable disease” as treatment had not actually started until after scan (b). The patient went on to have response (d). Patient 2 (e & f) are from a 66yr male with liver metastases from colorectal cancer with two MRI scans prior to onset of treatment two weeks apart as part of quality control (repeatability) for a clinical trial using dynamic contrast enhanced MR imaging (DCE-MRI) as an imaging biomarker. In this 2-week interval the small lesion actually increased by greater than 20%, enough to be categorised as disease progression using RECIST 1.1 guidelines.*



## **Reporting by the “rules”, RECIST etc.**

It is no use communicating that a patient has had a “good” response unless the patient and oncologist understand the meaning of “good”. Vagueness can occasionally be useful, for example “evidence of some response” sounds better than “stable disease” to a patient after 3 months of gruelling chemotherapy. However, this approach is no help when significant clinical or scientific decisions need to be made, and if the results of cancer trials are to have relevance to clinical practice. The WHO understood this when creating their first set of rules for the categorisation of tumour response in 1979<sup>62,63</sup>, and over the years there has been realisation that these rules need to be more specific, not only as regards reporting, but also for scan protocol and frequencies. This has resulted in multiple criteria, most prominently RECIST 1.1 and a variety of Lymphoma based criteria<sup>61,64,65</sup>. Changing the quality of investigations can have a radical effect on the interpretation of clinical trial data, and rules to ensure consistency in scanning and measurement are important. However, rigid application of these rules can reduce trial recruitment<sup>66</sup> and cause data loss through protocol violations, serving to make the study less relevant to the “real world”<sup>67,68</sup>. It is beyond the scope of this article to document the myriad ways of failing to report clinical research scans, except to say that getting the baseline pre-treatment scan correct makes follow-up considerably easier. We pick out three issues that affect the patient as well as the study.

1: Watch the small lesions: The original RECIST 1.0 publication states that progression in non-target lesions only is a rare phenomenon. This statement is not repeated in the 1.1 guidelines and, in our opinion, is false. Progression will often occur in small lesions, whilst the large lesions remain static, particularly if they are necrotic.

2: Never let clinically important information get lost in the “research” report: Defining response in categories means that relatively minor errors in measuring lesions may inappropriately categorise a patient as response or progression, particularly if lesions are small. Also, unmodified RECIST1.1 criteria do not take into account pseudo-progression or changes in contrast enhancement<sup>57,59</sup>. Our advice is to assess the scans clinically first, and if the measurements show an unexpected result, check them. It is acceptable to classify a scan as “equivocal” and continue therapy in many clinical trial protocols. Considering the patient when reporting scans for clinical trials is a recognised reason why trial data from the investigator site may differ from independent review<sup>69</sup>, but in our opinion, this is no bad thing.

3: Beware of “satisfaction of search”<sup>16</sup>: After the laborious task of measuring and comparing all lesions, the radiologist must still be alert to impending complications of cancer and cancer treatment.

## **Scan Protocol failure**

Clinical research protocols for cancer treatment generally require consistency of scanner, field of view, matrix, slice thickness and contrast protocol. This is not always possible in the real world, and there is little consistency in how cancer is imaged, for example the extent of scans required for lung cancer staging<sup>70</sup>. Unlike for magnetic resonance imaging, CT scans performed on modern equipment using different protocols can usually be compared adequately, but one problem that cannot be fixed is failure to scan a region of interest. This is a relatively common problem resulting in recalling of

patients, or being unable to compare apparently new findings on surveillance scans because of the limited extent of initial staging scans.

There are good reasons for limiting scan extent to reduce radiation dose, and historically it was also important to reduce x-ray tube heating and speed up scan appointments. Also, CT tariff costs may increase incrementally with increasing scan extent, despite little extra resource required. Radiologists should consider the benefits of the scan and scan extent balanced against any risk from the radiation dose, and the principles are clearly different for oncology radiology. Firstly, properly performed diagnostic CT does not cause direct harm to the patient; the risk is a theoretical probability of future harm (stochastic risk). There is, of course, risk due to improperly performed CT<sup>71</sup>. It is the authors' belief that the stochastic (random) risks from CT scans should not be unduly considered when deciding the diagnostic pathway of a patient with advanced cancer, and nor should inappropriate concern of small stochastic risks hamper the effective initial diagnostic work-up of a patient with significant clinical symptoms suggestive of a serious cancer diagnosis. However, we are not in favour of simply scanning cancer patients for the sake of it. Over-scanning incurs costs, diverts precious resources, and may even result in over treatment or other hazards due to false positive diagnoses. For example, there is good evidence that after successful first line treatment in potentially curable cancers that repeated scanning whilst asymptomatic achieves very little<sup>72</sup> and can result in harm from over investigation and even radiation risk<sup>73,74</sup>.

### **Concluding remarks on the "Discrepancy process"**

The interpretation of a radiologic study is rarely "black and white" and the conclusions are not always normal or abnormal, cancer or not cancer. The final report issued by a radiologist is influenced by many factors, including the information available at the time of reporting<sup>4</sup>, and this involves decision-making under conditions of uncertainty<sup>3</sup>. There is often an assumption that perfection is achievable, and that any error or discrepancy represents a "wrong that must be punished"<sup>75,76</sup>. The discrepancy meeting process aims to dispel this myth with an ethos of collective learning, individual improvement, systems improvement and ultimately patient benefit<sup>77</sup>. Early meeting recommendations required scoring of errors and group assessment of perceived patient harm<sup>78</sup>, but the artificial nature of the assessment made independent analysis difficult<sup>79</sup>. We have always resisted this approach as it discourages frank discussion and full participation. Furthermore, it may encourage a "blame" culture leading to "over-calling"<sup>78</sup>, resulting in unnecessary tests and potential morbidity to the patient. The Royal College of Radiologists have recognised this and new guidelines emphasise learning points and action plans<sup>78</sup>, not scoring error or judging blame.

Errors do need to be communicated to the perpetrator, and we have a "duty of candour" for significant clinical errors, requiring rapid communication to the physician and the patient<sup>80</sup>. This raises the concern of legal protection for discrepancy meetings, as this potentially exposes the perpetrator to legal action. Although "negligence" requires a "degree of error exceeding an acceptable norm"<sup>76</sup>, this is not easy to define and courts may treat false-negative errors as errors of negligence<sup>4</sup>. Therefore, despite the obvious advantages of such meetings as a learning process<sup>81</sup>, radiologists may avoid them. However, our experience of reviewing hundreds of discrepancies over the last 10 years, most minor and some major, is that we have no examples of a radiologist coming to

professional harm directly from the meeting process itself. This is because the “duty of candour” process is an independent responsibility and occurs separately. However, we do have examples where being able to say that a mistake has already been thoroughly peer-reviewed has helped in an apology to a patient. We also strongly believe that the process has improved our performance.

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