Be prepared for the unexpected; Hints, tips and tricks to prevent failures in making non protocol ct-scans.

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Learning objectives

To give an overview of things that should be thought about by making a CT scan.

To provide useful information which could result in a successful non-protocol CT examination.
Background

CT is the most upcoming when it comes to diagnostic imaging in hospitals over the last couple of years. It is a fast, accurate way to provide imaging which can give an answer to many clinical questions.

Many specialists prefer CT imaging in acute situations, for example trauma, ICU, or neurological patients. With these patients, every second could make the difference.

When there is a hospital, there is (most likely) one or more CT scanner(s), and when there is a CT scanner, there are (hospital adapted) CT scan protocols.

Most hospitals have optimized their CT protocols to give answers to almost every clinical question and therefore offer a great diversity.

This having said, in some cases, the clinical question is not located in a, well studied, CT scan protocol. Or the conditions of a patient prefers other measures. For example; Too many questions, two questions that are too far apart, not a standard intravenous catheter, etc.

A well trained radiographer is needed for these examples. A good knowledge in CT technology and anatomy/pathology is necessary to make a successful scan in these cases.

There are some hints, tips and tricks because of personal experiences or literature, to prevent failures in making non-protocol ct-scans.
A patient is referred for a CT scan through a specialist and hereby asks for your help in performing it. This is part of the daily work of a radiographer working on a CT scanner. Of course there is nothing wrong with that, but sometimes you are in some way unprepared. The problem(s) could be, Less data concerning the patient or a clinical question where you're simply don't have a standard ct scan protocol for. In short, this could may bounce. In the following presentation i hope to create something more clarity about performing non-protocol CT examinations.

What do you want to achieve with a CT scan?

You want initially to answer the clinical question. You want to achieve this with the lowest possible radiation dose (ALARA) and you want to minimize the contrast media use. The CT protocols, which are made with these aspects in mind, take cover a lot but sometimes this is not enough. There are moments where you need to improvise.

**Children**

Making CT scans of children is perhaps the most difficult of all. There are so many factors that influence your scan to a successful conclusion. You have (extra) take into account things like; contrast agent, timing, dose, movement.

In children, especially in babies, temporal resolution is often the biggest concern. Movement can be fatal for the assessment of your pictures and you do not want to allow this. The best way to achieve this by using the highest possible pitch with the lowest possible rotation time to perform the scan (also depending on the options for collimation of the CT scanner). The trick is to make a good trade-off and this is well thought about while the CT protocols were made, i hope, for the scanner.

**Movement**

The first thing you need to do is immobilise (small) children as much as possible. (figure 1)

This way you have one problem solved.

**Contrast**
When you have to use contrast media use this wisely. Overall do not use more than 2mL iodine per Kg bodyweight, slightly depending on the amount of iodine percentage (320mgI/mL).

If really necessary; when the performed scan is longer then the contrast media will go through in seconds you could do 3mL iodine per Kg.

But at lower kV settings contrast density increases.

Since in pediatric low kV scanning is preferred. Flow rate's do not need to be very high for (CT Angiography) scans. (figure 2)

So if we keep this in mind mostly the preferred dose of contrast media is more than enough. If you only have access to high percentage iodine contrast media it is good to think of the possibility to mix the media with saline (example; normal 10 mL at 1.0 p/s=10 s. mixed 50/50 at 1.0 p/s= 20 s contrast bolus with less density)

**Clinical question**

It sometimes happens that in children a CT scan is requested because they sometimes can't get a diagnose with, for example, ultrasound. In this case you do not know exactly what's going on. When there is asked for a CT scan with contrast media, ask the specialist if this mapping of the blood vessels, is either arterial, venous, or perhaps both. In the last case it is less worrisome, because if there is a change in the anatomy, it in the venous phase mostly likely go well, according to a standard protocol.

in the case of both; discuss whether this can be provided in one scan, use 2/3 contrast remembering the delay of venous enhancement and third just before actually starting the scan. This saves an initial dose reduction because of only one scan and you have a two in one phase scan.

Should only arterial scan occur, make sure that you always use bolus tracking. In most cases you do not know exactly how the contrast media will go and this way you it is certain that you will be set in a good timing of the bolus. In the case of a scan in the region of the thorax and/or abdomen plan premonitoring right into the heart, you reason of interest outside the patient and watch live with what is happening with the contrast media. This way you have complete control over when the scanning should start. Thinking also off the dose, turn the monitoring on the lowest possible kV and mAs value for the dose as much as possible. A standard monitoring is always far too high for children! See for example figure 3.

**Catheters**

An intra-venous catheter is preferably in the elbow, but that is not always the case.
When it is not possible to insert a catheter into the elbow of the patient but somewhere else, sometimes you have to think about the scanning delay and flow rate. Indeed, this may be affected it. The further a catheter is in the desired location in the elbow, the longer it obviously takes for the contrast media will come.

You should take into consideration when it concerns a scan in the arterial phase is the infusion into one of the blood vessels in the feet, then it is advisable to check what you can do with the flow velocity. Indeed, the contrast will in this case, be much later arterial than can be seen and it comes into the heart through the inferior vena cava. Because of this relatively large blood vessel the contrast will strongly loses the density because it will be mixed with a lot of blood. You should, in this case, increase the flow velocity maybe doubled, if possible.

Is there no way to, or in conjunction with, think also the kV setting. Can this still be lowered? What could give a gain in density of the contrast medium.

This can usually seen only in the case of a question in which there is a demand for the blood vessels. The picture will show more noise than usual, but you can wider the ww/wl settings.

But keep in mind that with lowering 20 kV increase the mAs value with 30% to maintain a certain resolution, however still with less total dose.

This is also the case in other catheters, such as a Venous Jugularis, Hickmann, or a port a cath (figure 4).

**Positioning**

In an ideal situation, the patient always does what you ask of him, but this is not always possible. When you want to perform a scan of the thorax and the patient can not raise his arms, you should take some things in count. In the case of the arms in your scan area, you will first need to calculate the necessary artifacts in your scan, unfortunately this will appear. But there are a few ways to reduce them there however. ATCM is required for each type of scanner, in other words on the basis of the scout view is a dose calculation made for the final scan. After the scout view image the dose should be observed prior to the scan to see if this has an expected value. If this is the case, fine, if it is not reposition the arms. Make sure in any case that the arms are as close as possible attached to the body, either on their stomach so they can be included in the calculation of the dose. when they are to far apart, they won't be included. In the final scan a low total dose will indicate which results in a reduction in resolution. Concerning a patient of> 90kg, you would be wise to increase the kV with 20 kV minimum, also thinking again to reduce the mAs value by 30%. Also, you need to take into account a reduction.
There are also cases where there is a combination scan required and a decision should be made between the arms up or down correctly. In this case it is a question of what has the preference? For example, is there a scan to be made around the neck and the thorax and goes primarily to the neck, then let your arms down and visa versa. Both are equally important? you can decide to have the arms down to do the neck scan, very quickly walk to the patient the arms up and scan thorax scan. I must say that this is not true for an arterial phase scan, there is limited in time.

**Cases**
Fig. 5: A patient with a huge dissection of the aorta.

References: Radiology, Hospital, Erasmus University Medical Center - Rotterdam/NL

Fig. 6: A patient with a huge dissection of the aorta.

References: Radiology, Hospital, Erasmus University Medical Center - Rotterdam/NL

In this case; if you had set a ROI into the thoracic aorta, the scan probably wasn't going to start because of the trigger that wouldn't go off.
**Fig. 7:** Patient with a LVAT (ventricular assist device)

**References:** Radiology, Hospital, Erasmus University Medical Center - Rotterdam/NL

Here we have a patient with an L-VAT. A good planning and more contrast media than normal is strongly required in this case. The contrast media easily goes faster away because of the L-VAT
**Fig. 8**

**References:** Radiology, Hospital, Erasmus University Medical Center - Rotterdam/NL

Figure 8-9-10 Shows a total filled vessel anatomy of the thorax.

Totall usage: 3.0ml/s iodine 45 ml, 5.0ml/s 75 ml, 5.0ml saline 45ml in this order. Beautifull images and a good overview of the vessels.
Fig. 9

References: Radiology, Hospital, Erasmus University Medical Center - Rotterdam/NL
Fig. 10

References: Radiology, Hospital, Erasmus University Medical Center - Rotterdam/NL

Fig. 11: monitoring
Fig. 12: 80 kV image

References: Radiology, Hospital, Erasmus University Medical Center - Rotterdam/NL
Fig. 13: 140 kV image

References: Radiology, Hospital, Erasmus University Medical Center - Rotterdam/NL
figure 11-12-13.

A CT scan performed on an small child ECMO
(extra corporeal membrane oxygenation)

figure 11 shows the monitoring constantly the contrast injection. Live monitoring gives all the information you need to know when starting the scan.
Figure 12 Dual Energy 80 kV optimal image contrast resolution  
Figure 13 Dual Energy 140 kV optimal image contrast resolution
Images for this section:

Fig. 1

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- At lower kV settings contrast density increases.
- Since in pediatric scanning low kV is preferred. Flow rate’s do not need to be very high for CT-Angiography scans.

Fig. 2

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**Fig. 5:** a patient with a huge dissection of the aorta

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Fig. 10

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**Fig. 12:** 80 kV image

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Fig. 13: 140 kV image

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Fig. 11: monitoring
Conclusion

Even if you think "i have covered myself for everything" there will always be some moments in wich you are not prepared for.

You can not secure yourself for eveything, and so it also is in making CT scans.

When you want something being done the right way, make sure yo prepare yourself as much as possible.

If a specialist wants a CT scan to be made of a patient, with a certain clinical question, he fully trusts the person who sits behind the buttons, it will being done the right way.

If the scanning is not a standard protocol but needs an improvisation, make sure you are prepared.

With this i mean; know what the CT scanner is capable of, know you're anatomy/pathology, get as many information of the patient as you can, have a discussion with the specialist(s) if necessary before beginning.

The information which is given in this presentation tackles out a few pitfalls and could help in preventing failures in making non protocol ct-scans.
References

Coronary computed tomography angiography: principles of contrast material administration.

Cardiac CT: technical considerations.