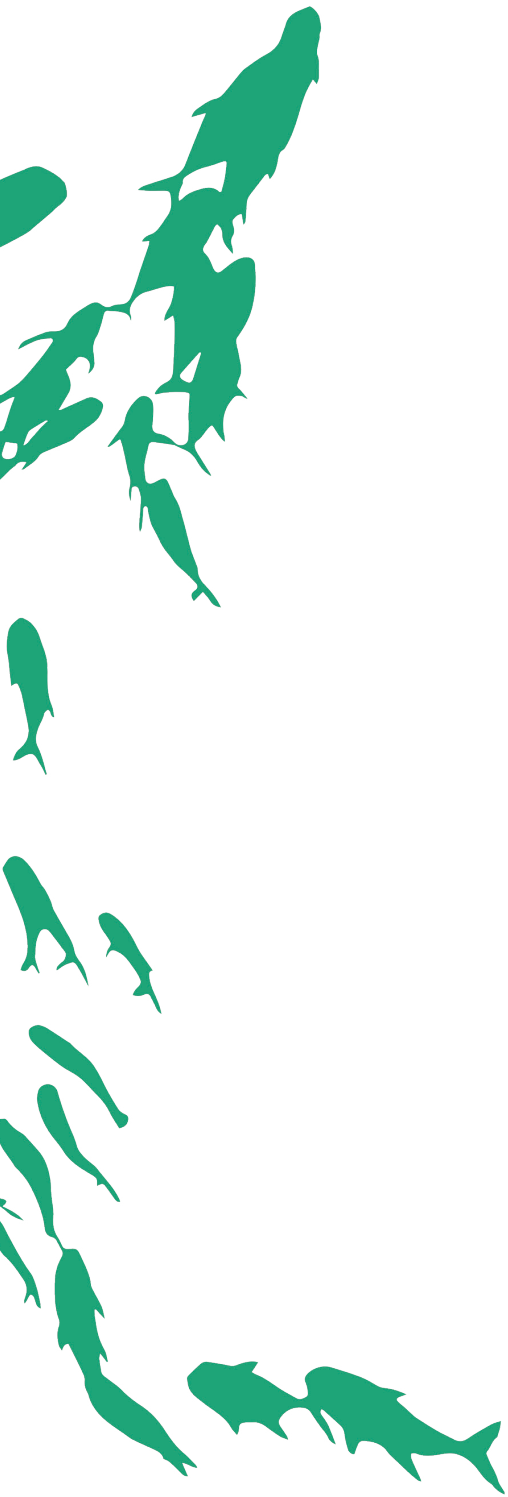
Computed tomography of the abdomen



CHAPTER 11

Scientific impact

11.1 Research

Radiation dose and contrast media (CM) together ensure image quality in (abdominal) computed tomography (CT) imaging. However, using a one size fits all protocol may not be the best tactic. Optimizing radiation and CM dose will result in individualized scan and CM protocols in which, ideally, each patient will receive the optimal amount of both to reach diagnostic image quality. In such optimization, however, the type of CT study performed must be taken into account. In vascular studies the iodine delivery rate (IDR, in gI/s) is considered the most decisive factor. For parenchymal studies, the CM volume (in ml) is the most important parameter to reach optimal enhancement of the target organ (1). The aim of the current thesis was to find the optimal radiation and CM dose for each patient in abdominal imaging. This thesis proposes a 10-to-10 rule of thumb to individualize scan and CM injection protocols. A 10 kV decrease in tube voltage should be accompanied by a 10 % decrease in IDR for vascular studies and a 10 % decrease in dosing factor for a parenchymal CT, and vice versa. Results of a randomized controlled trial (COMpLEx trial) confirmed this easy to implement rule of thumb in abdominal imaging.

To date a disagreement exists between the European and American guidelines regarding the necessity to pre-warm CM to body temperature before intravenous administration (2, 3). The current thesis provides high level evidence that pre-warming CM does not result in increased image quality, safety, or patient comfort in abdominal CT imaging (CATCHY trial). This result could improve work flow efficiency in daily clinical practice, as there may be no need to store CM in a warming cabinet.

Apart from body weight, tube voltage and CM temperature, this thesis proposes to add the patient characteristics age and kidney function to the parameters used for protocol optimization. In younger patients and patients in need of frequent scanning, radiation dose reduction is preferred, whereas patients with reduced kidney function (more frequently seen in the elderly population) may benefit more from CM dose reduction. These additional patient characteristics were evaluated in an animal feasibility study with promising results.

The present thesis tackles different parameters step by step. However, combining all pertinent factors into one protocol is challenging. Artificial intelligence (AI) could be the solution to further optimize daily workflow in the CT department. AI could for example, aid in radiation and CM protocol individualization, detect insufficient image quality at an early stage, and provide a warning signal upon the detection of an acute pathology requiring immediate viewing by a radiologist.

11.2 Relevance

In the past, a one-size fits all protocol was used for both radiation – tube voltage and tube current – and CM dose protocols. However, rapid technical developments made it possible to adapt tube current and tube voltage to the clinical question and patient body weight, substantially reducing radiation dose (4). In daily clinical routine worldwide, CM is still often administered in a one-size-fits all fashion. Previous studies from our group and of the present thesis show that individualizing the CM protocol based on body weight results in more homogeneous enhancement in cardiac, pulmonary artery, and abdominal imaging. Furthermore, a simultaneous reduction in total injected CM volume was achieved in a large percentage of the population (5, 6).

Radiation and CM dose are often treated as two separate entities. However, considering both parameters in conjunction opens new doors. The 10-to-10 rule offers an easy-to-use and readily implemented rule of thumb to adapt both parameters to one another. By introducing an opportunity to adapt either the radiation or the CM dose – depending on age, kidney function or the necessity for repetitive scanning – protocols can be further optimized based on individual risk assessment.

The present thesis provides a manual on how to individualize CT protocols in daily clinical practice. By applying the proposed rules, it is possible to reach sufficient image quality in each patient, every time, whilst maintaining the perfect balance between radiation and CM dose.

11.3 Target groups

There are four groups for which this thesis could be relevant.

1. *Radiologists*

Radiologists in general are aware of the fact that radiation and CM protocols influence image quality. However, there is too little awareness of how protocols influence important aspects such as lesion characterization. Different protocols – between hospitals, scanners, and moments in time – will result in different attenuation levels. In kidney lesions for example, attenuation predicts the likelihood of a malignant lesion. Therefore, homogeneity between and within patients is desirable in order to draw reliable conclusions from each scan. The current thesis provides an easy-to-use rule of thumb to reach such homogeneous enhancement in both vascular and abdominal CT imaging.

2. *Radiologic Technologists*

In the Netherlands, technicians are responsible for acquiring the scan according to protocols as determined by the radiologist. The information in the present thesis may give technician's more insight into why and how protocols are optimized. Furthermore, the suggestions made with regard to the introduction of AI may simplify their job.

3. *Referring physicians*

Clinicians are happy with a performed CT scan when it is easy to assess and has diagnostic image quality. In order to make sure that we can provide that 'pretty' CT scan, clinicians have to provide a scan indication, clinical background, and correct patient body weight and kidney function. While the current thesis may be too focused on the technical aspects of CT to capture the clinicians' imagination, a little glimpse into the world of the CT department would help them understand why these particular questions are asked of them.

4. The patient

Providing the patient with a CT scan with the highest achievable image quality, assists in diagnosing a diversity of diseases. In addition, decreasing radiation and CM dose diminishes the associated life time attributable cancer risk and possible drop in renal function. Last but not least, comfort is important to the patient. This is reflected in the fact that it was quite easy to find patients willing to participate in the CATCHY trial.

11.4 Activity

Most patients are somewhat familiar with X-ray imaging, but CT and Magnetic Resonance Imaging (MRI) are often confused with one another. In addition, most people do not really know what the work of a radiologist entails. At a first glance this shouldn't be a problem, but it may be beneficial for both referring physician and patient to know a little more about radiology. Referring physicians are informed through presentations. Patients may be reached through social media. Creating awareness of what is done in the CT department to reach diagnostic image quality may improve patients' understanding of procedures, and perhaps even the existence of waiting lists.

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