Reducing Radiation Exposure in Interventional Procedures

New developments in imaging systems are a step forward in increasing patient and staff safety.

BY OLIVIER H.J. KONING, MD, PhD; R.F.F. Van Den HAAK, MD;
B.A.N. VERHOEVEN, MD, PhD; R.M.M. Van LOENHOUT, MD; AND B.C. HAMANS, MSc

Radiation exposure in interventional procedures is an unavoidable side effect when performing state-of-the-art patient care. With the ever-increasing amount of endovascular treatment options for vascular patients, the amount of radiation to both the patient and the staff is rising. Increasing complexity of these endovascular treatment options and the growing incidence of obesity in vascular patients further adds to the problem of radiation exposure. The introduction of the hybrid operating room has enabled the combination of endovascular and open approaches with high image quality in a sterile environment with the highest level of care.

High image quality is necessary to enable these complex procedures to be performed on smaller and smaller platforms. These developments will further push the boundaries of new treatment options and technology.

> The hybrid operating room has enabled the combination of endovascular and open approaches with high image quality in a sterile environment with the highest level of care.

RADIATION EXPOSURE

For the patient, endovascular procedures mean minimally invasive treatment, decreased trauma, and therefore faster recovery. Repeat endovascular treatment is possible, even for patients who are unsuitable candidates for open surgery. The downside to these procedures is the associated radiation exposure. In straightforward procedures, this exposure is limited and, when considering the average age and comorbidity of the vascular patient, the negative stochastic and deterministic effects of radiation to these patients are limited. However, with increasingly complex procedures such as fenestrated stent grafting, obese patients and the fact that other, significantly younger, categories of patients such as vascular trauma patients are also treated endovascularly, it is even more important to pursue the "As Low As Reasonably Achievable" principle.

Acceptable Limits

Radiation exposure to the hospital staff is a major issue of concern. A long career in endovascular

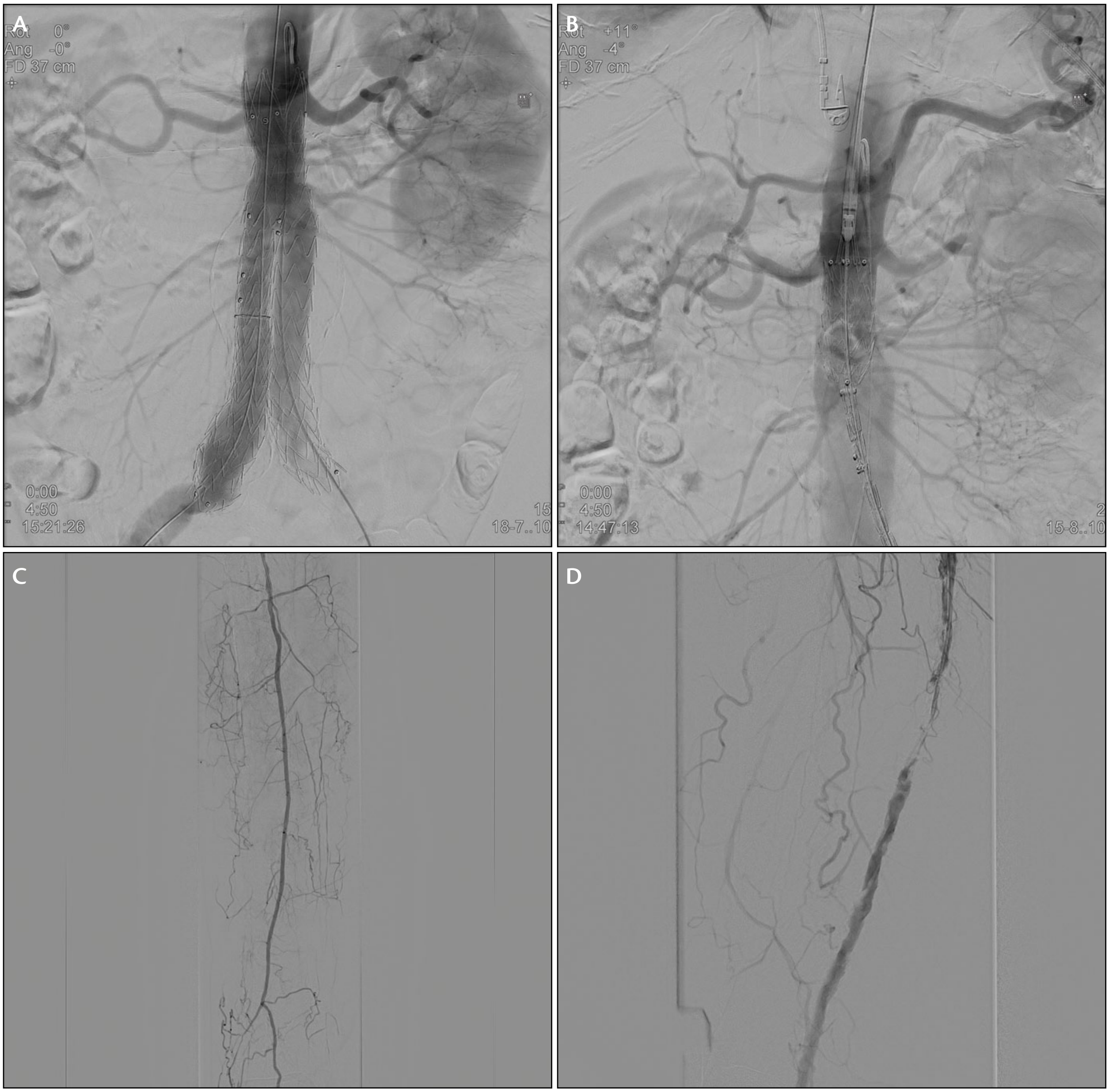

Figure 1. Examples of high-definition images despite reduced radiation doses: EVAR, with visible calcifications of the aortic wall (A, B); side branches and collaterals below the knee (C); recanalization of SFA, unmarked catheter, and collaterals are easily visible (D).

intervention leads to considerable amounts of radiation exposure. Recent insight from epidemiological research suggests that limits for deterministic effects such as cataract are easily achieved during an active career of over 35 years in this field. Accepted limits of yearly exposure for professionals have therefore been decreased in the last few years to 20 mSv/year averaged over a period of 5 years, with no single year exceeding 50 mSv. Personal protection with lead screens at the table, a lead apron, and lead glasses are important to reduce radiation exposure. During complex procedures such as fenestrated stent graft implantation, however, the practical implementation of these measures may be cumbersome. This is especially true in the hybrid operating room where the patient is surrounded by various equipment such as monitoring and interventional devices. For practical feasibility of these procedures, it may be necessary to

New dose-reduction technologies are necessary to lessen the amount of radiation for both individual patients and staff during endovascular procedures.

remove the lead screens, leading to increased radiation exposure of the staff. Furthermore, long-term effects of wearing heavy lead aprons can lead to health complaints in health care providers. Reducing radiation exposure could possibly lead to reduction of the lead mass in aprons, reducing weight and thereby physical burden to the staff.

DOSE REDUCTION

New dose-reduction technologies are necessary to lessen the amount of radiation for both individual patients and staff during endovascular procedures. A lower x-ray dose leads to fewer potential patient complications from radiation exposure. A lower patient entrance dose leads to decreased scatter radiation, which reduces long-term health risks for hospital staff. A lower x-ray dose therefore enables obese and high-risk patients to undergo longer procedures without excessive procedural dose increase.

Unfortunately, reducing radiation exposure without improving image processing will lead to poor image quality. This problem would make accurate diagnosis more difficult and could decrease the accuracy of endovascular interventions. To help address this concern, Philips Healthcare has developed a new system with ClarityIQ technology (AlluraClarity, Best, The Netherlands), which has resulted in an ability to lower the required radiation exposure without losing image quality and without changing the workflow of the physician.

ClarityIQ is an x-ray imaging technology that combines advanced real-time image noise reduction algorithms with state-of-the-art hardware to reduce patient entrance dose significantly. This is realized by anatomy-specific optimization of the full acquisition chain (grid switch, beam filtering, pulse width, spot size, detector and image processing engine) for every clinical task individually. More than 500 system parameters are fine-tuned for each application. It is possible to filter out more x-ray radiation, use smaller focal spot sizes, and shorter pulses, thereby fully utilizing the capabilities of the x-ray tube. In addition to patient entrance dose reduction, the image quality is improved through automatic real-time motion compensation and spatial and temporal noise reduction in subtraction imaging (Figure 1).

ClarityIQ Upgrade

This poses the question whether this system really reduces the total amount of radiation dose for the patients and staff. In our hospital, Jeroen Bosch Ziekenhuis ('s-Hertogenbosch, The Netherlands), we conducted a research project to determine the effect of this system upgrade on patient and staff radiation dose. The ClarityIQ upgrade was installed in our Allura FD20 system in October 2012. We prospectively measured patient dose (air kerma and dose area product) during interventional procedures in the months before and after the upgrade. The staff dose (mSv) was also monitored with the blinded use of the DoseAware system (Philips Healthcare), a real-time radiation exposure measurement tool.

CONCLUSION

The results of our study are currently being processed for scientific publication. Our initial findings indicate that there is a substantial radiation dose reduction without any change in the way of working or inconvenience during interventional procedures. According to these preliminary results, up to 75% of the radiation dose to staff and patient could be reduced. Image quality remained excellent.

Advances in endovascular therapy aim to improve patient outcome and procedural success. However, with the latest generation in imaging systems, we also see promise in increasing patient and staff safety without sacrificing the imaging quality required to provide optimal care. ■

Olivier H.J. Koning, MD, PhD, is with Jeroen Bosch Hospital, 's-Hertogenbosch, the Netherlands. He has disclosed no financial interest related to this article. Dr. Koning may be reached at o.koning@jbz.nl.

R.F.F. van den Haak, MD, is with Jeroen Bosch Hospital, 's-Hertogenbosch, the Netherlands. He has disclosed no financial interest related to this article.

B.A.N. Verhoeven, MD, PhD, is with Jeroen Bosch Hospital, 's-Hertogenbosch, the Netherlands. He has disclosed no financial interest related to this article.

R.M.M. van Loenhout, MD, is with Jeroen Bosch Hospital, 's-Hertogenbosch, the Netherlands. He has disclosed no financial interest related to this article.

B.C. Hamans, MSc, is with Jeroen Bosch Hospital, 's-Hertogenbosch, the Netherlands. He has disclosed no financial interest related to this article.