Digital Variance Angiography,

a technological breakthrough in X-ray angiography

(white paper)

Summary: Digital Variance Angiography (DVA) is a proprietary innovative parametric imaging method that outperforms Digital Subtraction Angiography (DSA) in vascular imaging in the following three aspects: enhanced image quality, X-ray dose reduction, and decrease of contrast agent use. DVA technology is implemented in the CE IIa marked and FDA approved Kinepict Medical Imaging Tool, available for use in the operating room in Europe and the USA.

Colour-coded DVA image of a hepatic tumour (courtesy of Prof Thomas Vogl, Uniklinik Frankfurt)

Cardiovascular disorders are the leading cause of death worldwide. Their diagnosis and treatment are key objectives of the global healthcare systems. Currently, Digital Subtraction Angiography (DSA) is the imaging method used for interventional radiology to visualise blood vessels in cardiovascular disorders – however, the image quality is not always appropriate (CO2 angiography) and the iodinated contrast media (ICM) and radiation applied during the procedure might cause complications for patients. A solution might be Digital Variance Angiography (DVA), a new image processing technology developed recently by Kinepict Health Ltd. The method is based on the principles of kinetic imaging [Szigeti et al, 2014], thereby it can obtain more information from medical examinations using penetrating radiation than the currently used image processing algorithms.

In 2D X-ray angiography, the gold standard is DSA, which records a contrast-enhanced image series and subtracts one of these images (the mask) from the other frames. These subtracted images compose the DSA video and their appropriate integration yields the DSA image. In contrast, DVA uses all frames of an unsubtracted series and calculates the standard deviation of intensity for each pixel. This **proprietary algorithm** enhances the functional motion-related information (i.e. the flow of contrast agents) but suppresses the noise, therefore the contrast-to-noise ratio (CNR), and consequently the **image quality is greatly improved** compared to

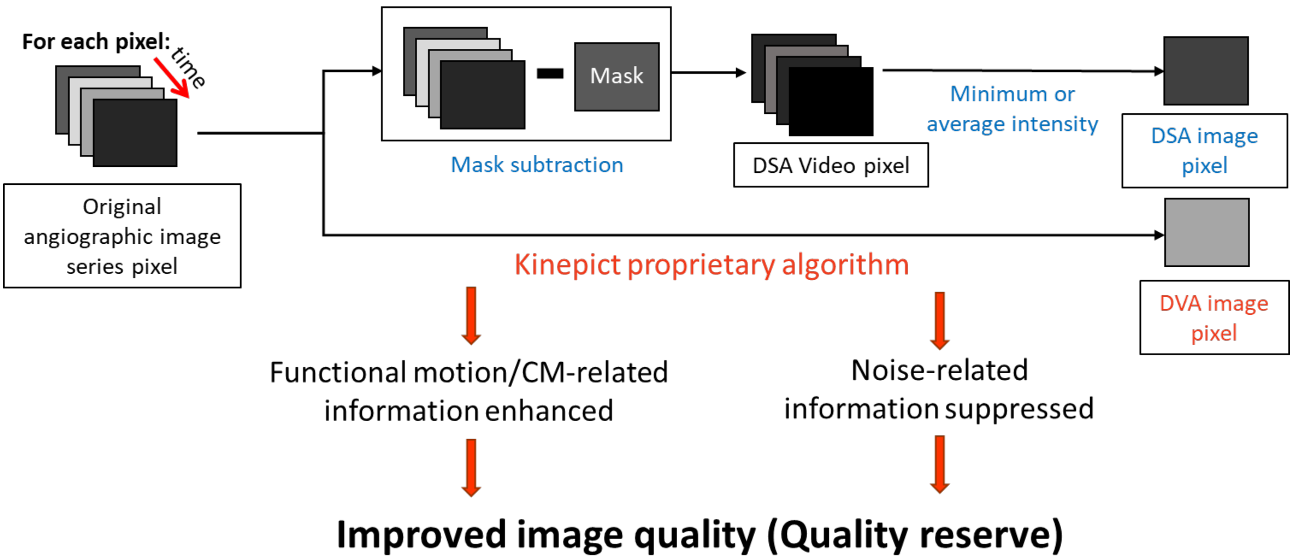


Figure 1. Comparison of the principles of DSA and DVA image processing technology.

DSA, providing a quality reserve (Figure 1).

This quality reserve was verified in two recent clinical studies, where DVA provided higher CNR and better image quality than DSA in lower limb angiography using either iodinated contrast media [Gyano et al, 2019] or carbon dioxide [Orias et al, 2019] as contrast agent.

The most important benefit of DVA is that the quality reserve can be used for **dose management**, i.e. for the reduction of radiation exposure or contrast media use. The dose management capabilities of DVA were investigated in two clinical studies. The first study [Orias et al, submitted] investigated the possibility of **contrast media reduction** in X-ray carotid angiography. The authors applied two protocols; a normal one with 6 ml and a reduced one with 3 ml iodinated contrast media (ICM). According to the results, DVA provided better image quality than DSA in both protocols. While the reduction of ICM volume resulted in a very significant deterioration of DSA image quality, it had no effect on DVA image quality, indicating that the quality reserve of DVA allows a 50% ICM reduction without affecting the quality of angiograms (Figure 2).

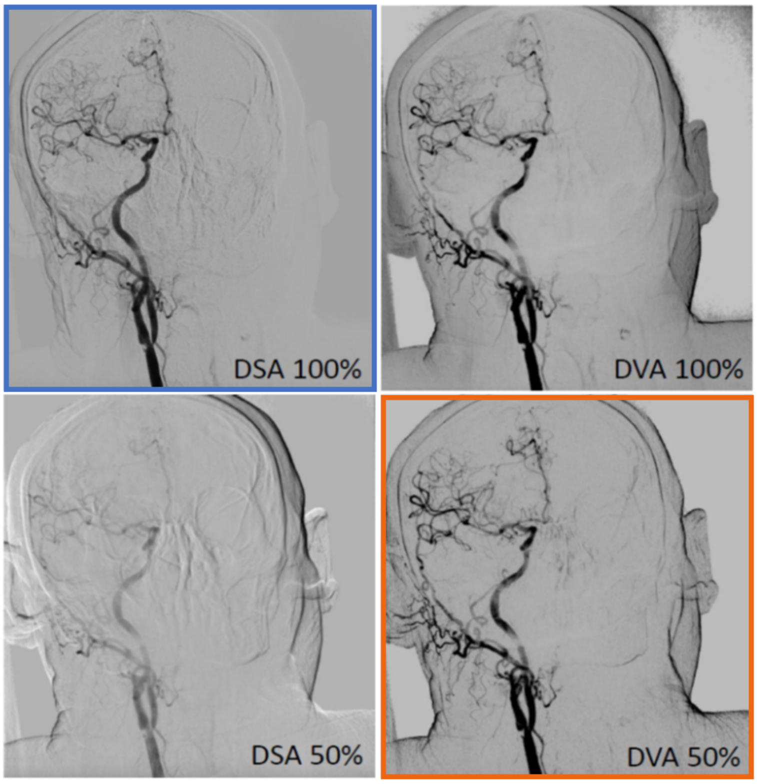
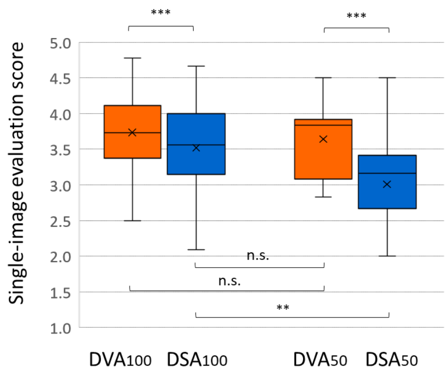
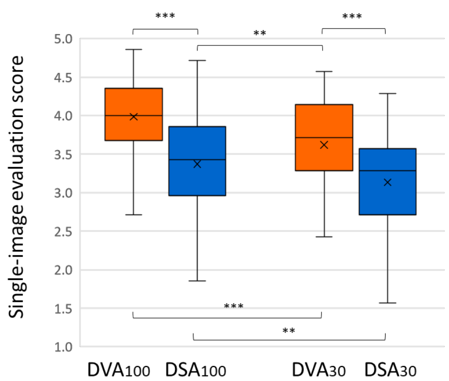


Figure 2. **ICM reduction.** Comparison of representative images obtained with the standard (100%, 6 ml ICM) and low-dose (50%, 3 ml ICM) protocols. Images were taken from the same patient and the same direction in two runs. All available image quality enhancement techniques (like PixelShift or noise filtering) were applied and brightness and contrast settings were equalized for all 4 images. The graph shows the results of a visual evaluation by 5 independent experts using a 5-grade Likert scale. Abbreviations: DSA: Digital Subtraction Angiography; DVA: Digital Variance Angiography.



The second study [Gyano et al, submitted] investigated the possibility of **radiation exposure reduction** in lower limb angiography. Again, a normal (1.2 µGy/frame) and a reduced (0.36 µGy/frame) protocol were used. The results show that DVA images obtained with the low dose protocol provide similar or even better image quality than DSA images with the normal dose, indicating that the quality reserve of DVA allows 70 % radiation dose reduction under these conditions (Figure 3).

Figure 3. **Radiation exposure reduction.** Comparison of representative normal dose (1.2 µGy/frame, 100%) DSA and low-dose (0.36 µGy/frame, 30%) DVA images obtained in the crural region. The corresponding Image pairs were taken from the same patient and the same direction in two consecutive runs. Brightness/contrast adjustments and pixel shift were applied to DSA and DVA images using the Siemens Syngo and the Kinepict workstation, respectively. The graph shows the results of a visual evaluation by 7 independent experts using a 5-grade Likert scale. Abbreviations: DSA: Digital Subtraction Angiography; DVA: Digital Variance Angiography.



The advantages of DVA are the most obvious in carbon dioxide angiography, where both the quality enhancement and dose management capabilities can be observed (Figure 4).

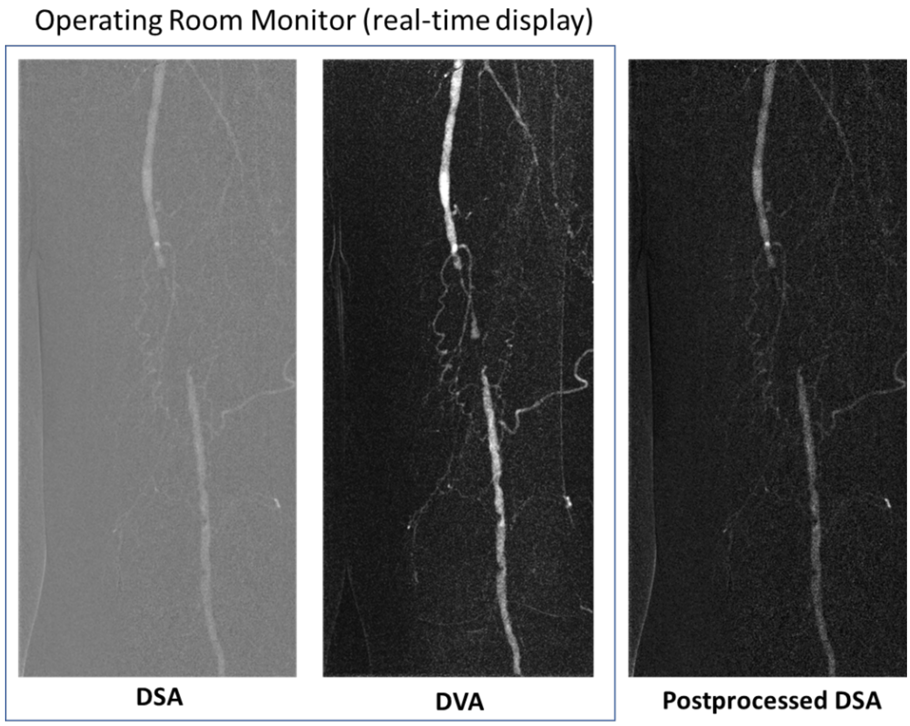


Figure 4. Quality enhancement and dose management in carbon dioxide angiography. The left panel shows the DSA, the middle the DVA image. These appear in real-time on the operating room monitor. The right image shows the best available DSA image after postprocessing. The DVA image provides a more detailed view of the high degree femoro-popliteal stenosis and occlusion. The collaterals are also more visible. The dose management potential is perhaps more important since these images were acquired with a specific CO_2 protocol (Evenflow, Siemens) but instead of the factory preset 7.5 FPS only at 1 FPS, resulting in a huge dose reduction during the procedure. Taken from Gyano et al, 2020.

DVA technology is implemented in the Kinepict Medical Imaging Tool: X-Safe (Kinepict Health Ltd, Budapest). This is an angiography platform-independent software with a class IIa CE mark and FDA approval. Integration of the Kinepict workstation into an angiography system provides a real-time operation during the intervention (Figure 5).

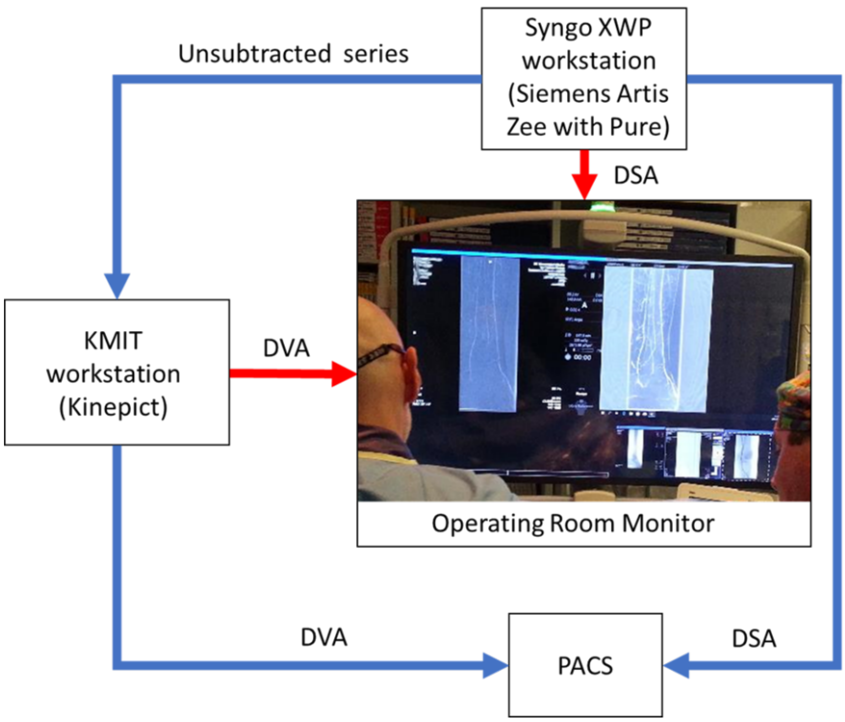


Figure 5. Integration of the Kinepict Medical Imaging Tool (KMIT) into an angiography suite (in this example with a Siemens Artis Zee with Pure system). KMIT runs on an appropriately configured desktop (Intel Core i7 processor, 16 MB DDR4 RAM, 256 GB SSD). The Kinepict workstation receives the unsubtracted raw image series in DICOM format via the local area network (LAN) and sends back the processed files automatically to the operating room (OR) monitor via a video cable. The DVA image (right side of the monitor) appears within 1-2 sec and can be used simultaneously with the DSA image (left side of the monitor). The presented DVA image can be post-processed (pixel shift, brightness/contrast settings) on the OR screen, if necessary. For archiving purposes, the DVA files can be saved to the PACS via the LAN. Taken from Gyano et al, 2020.

The KMIT workstation can be connected theoretically with any angiography systems. So far, Siemens, GE and Philips suits have been tested in Hungary, Germany and Austria. The software is clinically validated and used for daily routine work at two Hungarian sites.

References

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