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The use of virtual resources in preoperative preparation of infrarenal aneurysms: exploring the OsiriX's potential

O uso de recursos virtuais na preparação pré-operatória de aneurismas infrarrenais: explorando o potencial do OsiriX

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Abstract

Introduction: **In the past few years, the increase of endovascular surgeons' interest on tomography image edition through softwares is marked specially when it concerns to its use on pre-operatory study for endovascular aneurysm repair. It is presumed that the bigger the number of informations extracted from the tomography exam and its three-dimensional reconstruction, the smaller is the need of patient's exposure to contrast, as well as the its exposure and the surgical team to radiation. Concepts of image manipulation on the OsiriX software with volume reconstruction of tridimensional tomographic scans of virtual fluoroscopy were used.**

Methods: **Through manipulation of multi-slice tomography images under three-dimensional reconstruction on software, it was able to modify values of the exam's dose-irradiated distribution. These volume reconstruction presets were saved as Virtual Fluoroscopy, reproducible upon any OsiriX platform. It was able to construct a biplanar image appearing to the patient's operatory fluoroscopy. When compared to the intraoperatory angiography, the images were alike.**

Discussion: **Dose-irradiated distribution data manipulation allowed to visualize as opaque bone surfaces and transparent low-dose radiation's areas (viscerae). Thus, under previously marked renal arteries, it was possible to predict it's anatomical positioning related to visualization under real fluoroscopy. Foretelling the better positioning of the C-arm through this technique enables to obtain images with the minimum influence of parallax effect. It is believed that it supports to assess the renal arteries topographic positioning on a bi-dimensional intraoperatory image. The need of frequent angiographies to localize the renal arteries is reduced, decreasing the exposure to contrast on vulnerable patients.**

Descriptores: **Endovascular Procedures. Aortic Aneurysm, abdominal. Multidetector Computed Tomography. User-Computer Interface. Fluoroscopy. Pilot Projects.**

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Abbreviations, acronyms & symbols	
DICOM	Digital Imaging and Communications in Medicine
AAA	Abdominal Aortic Aneurysm
MPR	Multiplanar reconstruction
MIP	Maximum Intensity Projection
3D	Tridimensional
TC	Computed Tomography

Resumo

Introdução: **Desde os últimos anos, tem crescido o interesse dos cirurgiões vasculares com prática em cirurgia endovascular na utilização de softwares de manipulação de imagens tomográficas, principalmente quando se refere à sua utilização no reparo endovascular dos aneurismas de aorta abdominal infrarrenais. Assim, o pós-processamento das imagens tornou-se uma grande ferramenta na interpretação e documentação das alterações, melhorando a produtividade e a precisão das informações, utilizando volumes cada vez menores de contraste iodado no planejamento e execução do tratamento endovascular. Da mesma forma, menor é a exposição à radiação ionizante no intraoperatório. Divulgam-se os resultados iniciais da análise da viabilidade da manipulação de imagens tomográficas no *software* OsiriX por meio da fluoroscopia virtual.**

Métodos: **Através da manipulação de imagens de cortes tomográficos finos sob-reconstrução tridimensional por volume, foi possível manipular valores de projeção da distribuição de dose irradiada. A esta configuração, foi atribuído o nome de *Virtual Fluoroscopy*, formato reprodutível em qualquer plataforma OsiriX. Com isto, obteve-se uma imagem biplanar aparentemente a uma fluoroscopia operatória do doente. Quando comparadas à angiografia e fluoroscopia intraoperatória, estas imagens revelaram-se equivalentes.**

Discussão: **A manipulação de dados de distribuição da dose irradiada em uma superfície permite que se visualizem como opacas áreas de alto contraste (como superfícies ósseas) e como transparentes valores de baixa atenuação (partes moles). Orientados por marcações nas artérias renais, pode-se prever minuciosamente o seu posicionamento anatômico em relação à sua visualização sob fluoroscopia. Outrossim, a antecipação do correto posicionamento do aparelho de radioscopia com o uso desta técnica permite a obtenção da imagem com o mínimo de interferência do efeito parallax. Com isso, acreditamos ser possível estimar o posicionamento topográfico das artérias renais em imagem bidimensional intraoperatória. Consegue-se reduzir o número de angiografias na tentativa de se obter a melhor imagem que forneça a localização das artérias renais e do colo do aneurisma, reduzindo sobrecarga renal em pacientes vulneráveis.**

Descritores: **Procedimentos Endovasculares. Aneurisma da Aorta Abdominal. Tomografia Computadorizada Multidetectores. Interface Usuário-Computador. Fluoroscopia. Projetos Piloto.**

INTRODUCTION

Since last few years, the interest of vascular surgeons with endovascular surgery practice has grown in the use of image manipulation software DICOM (Digital Imaging and Communications in Medicine) on computed tomography (CT), especially when referring to its use in endovascular preoperative preparation of infrarenal abdominal aortic aneurysm (AAA).

With the adoption of high-resolution multislice CT scans and the increased availability of applications reconstructions equipment protocols, postprocessing of images has become a great tool that assists the interpretation and documentation of changes, improving productivity and accuracy of information.

In multichannel detectors equipment, efficient transmission systems, processing and storage of data and the refined engineering enable the reduction in acquisition time and improved spatial resolution in the longitudinal axis of the images. The latter is dependent on the voxel size (the smallest unit volume point in a digital image) that is in turn defined by the slice thickness[1].

Currently, CT is one of the most important methods for diagnosis and monitoring of vascular diseases; and its performance is due to the spatial and temporal resolutions, associated with inherent attenuation of the vascular lumen obtained by the administration of intravenous contrast. There is no type of reconstruction more effective than the other, but all have their features and directions, and often the use of more than one type suitable for the demonstration of a pathology is necessary[1]. Thinner CT sections allow the three-dimensional reconstruction reaches a level of excellence in detail and quality, using increasingly smaller volumes of iodinated contrast due to the increased speed of image capture obtained[2].

The exposure of the patient to a minimum volume of iodinated contrast is one of the concerns more present during the planning and implementation of endovascular aneurysm repair, since the incidence of contrast-induced nephropathy in vulnerable patients - patients with renal dysfunction, diabetic nephropathy, dehydration, hypotension, heart failure, octogenarians, among others - can vary from 12 50%. It is defined as a 25% increase in baseline serum creatinine and is usually transient. However, it can lead to undesirable clinical outcomes such as prolonged hospitalization, clinical complications during hospitalization and increased hospital mortality. While the risk of nephropathy is dose-dependent, it is recommended in patients with glomerular filtration rate less than 60% that the volume of administered contrast is less than 100 ml[3].

Thus, we can assume that the greater the amount of information is extracted from the CT scan and its three-dimensional reconstruction, the less the need for contrast exposure during the intraoperative period, and the lower the exposure of the patient and the surgical team to radiation ionizing.

We believe that in addition to precise measurement - such as diameters, lengths and angles[1] - and the analysis of the characteristics of the aneurysm, it is possible to get better use of information such as topographic positioning of visceral arteries and their respective references of radioscopic viewing since the reconstruction of tomographic sections of smaller thicknesses allows the scanned virtual reproduction of the patient and his disease[4].

METHODS

We disclosed herein the initial results of the analysis of the feasibility of tomographic image manipulation software (OsiriX MD) with the use of virtual fluoroscopy. This technique has practical significance with easy incorporation into routine endovascular planning. We used it as an aid in predic-

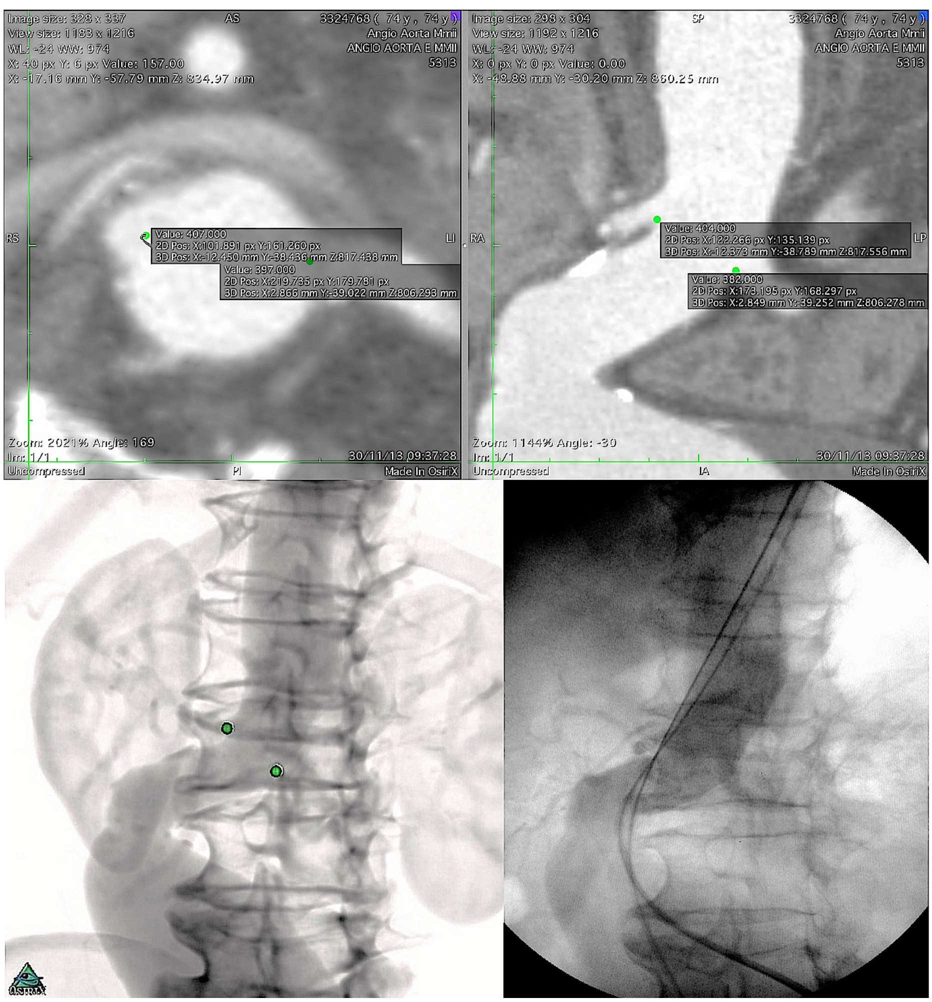

Fig. 1 - Up - ostial renal artery markings in axial projection, with auxiliary view on longitudinal section (at right).
Below – At left, preoperative virtual fluoroscopy, with representation of the markings of the renal arteries, previously performed on axial slices. At right, intraoperative angiography: Please note that there is minimal interference of the parallax effect in the middle of the image

tion of the intra luminal placement of angiographic catheters and fluoroscopy unit during endovascular aortic aneurysms repair. A number of cases from 14 studies were collected, with promising results. The steps for preparing the configuration of virtual fluoroscopy and illustrations of the technique used in two of our cases.

Multichannel CT scans of patients undergoing endovascular infrarenal AAA at the Center for Highly Complex Endovascular Surgery, State University of Campinas, August to December 2013 were analyzed.

We used three-dimensional multiplanar reconstruction through DICOM images manipulation software (OsiriX MD) for analysis of aneurysms in series of images with thin 1-3 mm CT slices, intravenous iodinated contrast in arterial phase. Initially, markings on the renal arteries on axial projections were made, through the point command. This feature also signals the voxel in the image examined, so that is subsequently represented in any view, either axial or through both volume or multiplanar three-dimensional reconstruction (Figures 1 and 2).

In a 3D reconstruction by volume rendering, using the pre-defined Bone CT reconstruction and Pencil, we can modify the tomographic values of windowing, CLUT (color lookup table) and shading which in turn define brightness, contrast and color range of the image (Figure 3).

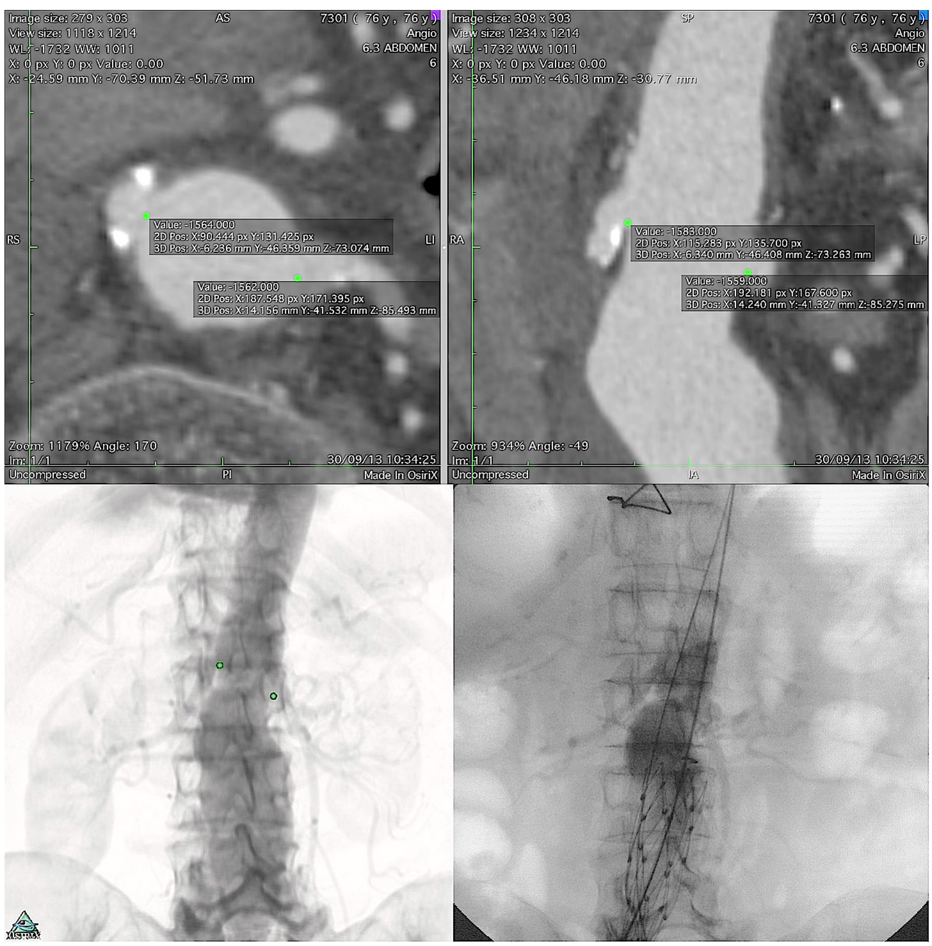

Fig. 2 - Up - ostial renal artery markings in axial projection, with auxiliary view on longitudinal section (at right).
Below – At left, preoperative virtual fluoroscopy, with representation of the markings of the renal arteries, previously performed on axial slices. At right, intraoperative angiography: Also note the little influence of the main body of the endoprosthesis on the angular position in the visualization of renal arteries studied (in this case, Endologix AFX endoprosthesis)

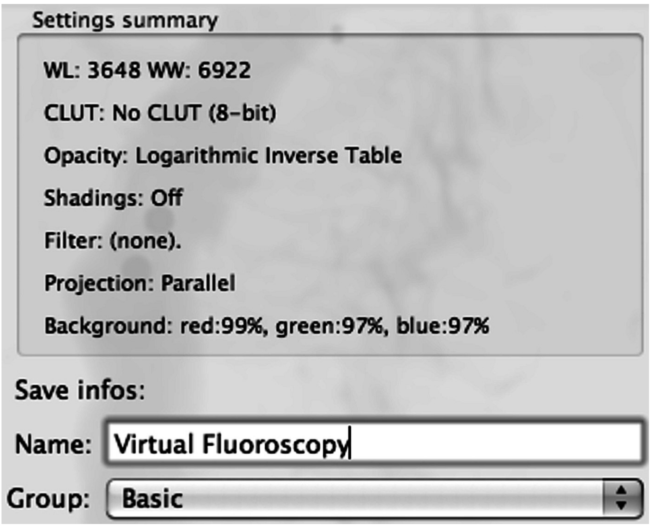

Fig. 3 - Manual configuration of the preset 3D at OsiriX MD, named as Virtual Fluoroscopy. Window width (WW - the window width) sets the number of gray scales shown and window level (WL - the window level) sets the value of the average gray scale of this width. CLUT (color look up table - lookup table of colors) defines a mechanism of the software used to transform a range of input color to another color range[5]. When represented as No-CLUT in 8-bit, it displays images in grayscale. Turning off the shading feature the effect of light is reduced (to enhance the three dimensional appearance) favoring the perception of the final image as biplanar, as it is conventional in a fluoroscopy. This configuration may be republished in any OsiriX platform

At this configuration, the name of Virtual Fluoroscopy was assigned and reprinted in other OsiriX platforms, always yielding the same two-dimensional image in a single tomographic volume, thus becoming a reproducible format. Once the series of images is subjected to a reconstruction using the software - with advance signaling of voxel through the point - this is shown in three-dimensional and multiplanar images, allowing a more detailed study of the reference point at odd angles of the human anatomy and its topography.

The images were reproduced and placements achieved intraoperatively, revealing themselves equivalent (Figures 1 and 2).

DISCUSSION

The reconstruction volume approaches the attenuation coefficient of the voxel at a scale of color and degree of opacity (transparency) along the axes. It preserves the information of depth, and shows a better spatial distribution of structures. In a traditional reconstruction, this three-dimensional effect is enhanced by light (shading)[1].

The manipulation of these data (the dose distribution radiating to a surface) allows visualization of the maximum intensity projection (MIP), which demonstrates the densest voxel (higher attenuation coefficient) - which are displayed as opaque areas of high contrast (as bone surfaces) and as transparent values of low attenuation (soft tissue). Even if in the plan above the overlay to structures that compete with the density of the aorta exists, this is a desirable effect when the aim is a three-dimensional reconstruction that simulates a simple biplane fluoroscopy in grayscale of the studied area.

The ideal positioning of the fluoroscopy unit during the surgical procedure may be different than expected during the preoperative study, in that the aneurysm possibly shorten or lengthen higher than expected. However, although it is described that the angulation of the neck of the aneurysm can be changed, the angular position does not change even under the influence of the inserted guide wire or endoprosthesis itself[6].

Thus, guided by the initial markings of the renal arteries, we can minutely predict its anatomical position in relation to its visualization under fluoroscopy, as well as estimate the location of the aneurysm neck, considered the starting point for determining the intraoperative positioning of surgical arch and angiographic intraluminal catheter.

Additionally, one can associate corrections of projections of anteroposterior and rotational angle of the neck, since the tortuosity of the aneurysm causes typical changes in the anatomy of the patient and are particularly challenging in the endovascular treatment. Furthermore, the anticipation of the correct positioning and centering of the fluoroscopy device using this technique allows obtaining image with minimal interference from the parallax effect (where there is a difference in the apparent position of an object when viewed under overlay planes).

Thus we believe it is possible, through the virtual fluoroscopy under manipulation of DICOM images in software, estimating the topographic position of the renal arteries in intraoperative two-dimensional image (angiography and fluoroscopy). Similarly, when displaying a virtual fluoroscopy tomographically, one can reduce the number of intraoperative angiography in an attempt to obtain the best dimensional angiographic image that provides the location of the renal arteries and the aneurysm neck.

The closer this angiographic reproduction to virtual view of fluoroscopy the more careful is the surgeon search for positioning the renal arteries, and the better will be the use of the aneurysm neck for fastening and sealing of the endoprosthesis, being more accurate its release while the total volume of contrast used is smaller and reducing renal overload in vulnerable patients.

New ways to adapt this software has increasing by expanding its use to new tasks. Our proposal is to create familiarity of professionals and encourage demystified practice of this computer program, an essential tool in surgical planning, where more and more procedures are guided by images.

Authors' roles & responsibilities	
GJDPM	Statistical analysis; final approval of the manuscript; conception and design of the study; implementation of operations and/or experiments; writing of the manuscript or revising it critically for its content
AMOD	Realization of operations and/or experiments; writing of the manuscript or revising it critically for its content
ATG	Final approval of the manuscript; writing of the manuscript or revising it critically for its content

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