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Difficult Renal Puncture: Geometrical Study

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Abstract :-

- **Background : The fluoroscopic guidance of percutaneous nephrolithotomy (PCNL) is a worldwide known procedure. Currently, more and more practitioners perform renal puncture in monoplanar fluoroscopic projection without need of moving the C-arm.**

The depression of the tip of he calyx is the proof of the perfect position of the needle.

However, in the case of dificult renal puncture, the surgeon or the radiologist is forced to manipulate the C-arm to delineate the position of the needle either it is anterior or posterior to the calyx.

The interpretation of the fluoroscopic view is still sometimes subject to confusion especially for nonexpert urologists.

- **Results : the understanding of fluoroscopic findings is based on geometrical considerations. the authors propose a well-illustrated essay trying to explain the movement of the C-arm in case of failed calyceal puncture in diferent directions.**

- **Conclusion : the surgeon or the radiologist needs after asesement of the first puncture, to move the C-arm in his preferred plan to delineate precisely in which location is the needle in relation to the calyx and adjust accordingly the position of the needle.**

Keywords :- *Image guided surgery, urinary stone, fluoroscopy, percutaneous nephrolithotomy, percutaneous nephrostomy.*

I. INTRODUCTION

Fluoroscopic guidance is the cornerstone of PCNL which still an unmissable technique in stone surgery.

From a radiological point of view, Fluoroscopy provides real-time, interactive X-ray projection imaging. Fluoroscopic procedures consist of using an X-ray generator prsoviding alow dose X-ray beam, an X-ray detector to detect the X-ray pattern emergingfrom the patient body afterremoval of scattered radiation, and an image intensifier to create an image projection of radiopaque structures (1).

Fluoroscopyis a valuable and reliable tool formany image-guided surgical procedures (2, 3, 4).

In the PCNL procedure, all initial steps are dependent on fluoroscopy guidance.

The puncture of the targeted calyx can be done by ultrasound. However, one-shot or gradual path dilation and the introduction of the access sheath are entirely dependent on fluoroscopic guidance.

In fact, by providing a real-time localization and interaction of radiopaque structures (opacifiedrenalcalyx, puncture needle, guide wires, Amplatzsheath, ureteralstents,..) fluoroscopic imaging is essential for the feasibility and safety of the intervention (5).

Kidney puncture on fluoroscopy guidance, in particular, remains the most challenging procedure and the most at risk of failure.

A failed or difficult puncture leads to repetitive attempts which increases the risk of bleeding and radiation exposure.

Also, the expansion of percutaneous indications with the advent of mini and microinstruments is leading surgeons to puncture increasingly non dilated cavities, more and more difficult to puncture (6).

Failure of the first punctures can sometimes lead the excretory cavities to collapse giving less chance of success of subsequent punctures.

Thus, the mastery of the puncture technique whatever its nature must be perfect and based on valid theoretical knowledge.

The triangulation technique is among the most used techniques for puncture of the targeted calyx (7).

It is based on geometrical concepts to correct the absence of the third dimension in the biplanar projection.

Currently, more urologist in the case of dilated calyx are convinced that monoplanar vertical fluoroscopic view is suffisent to puncture the targeted calyx (8,9).

In the case of non dilated calyx or complex calyceal anatomy, the movement of C-arm is of paramount importance to clarify the position of the needle according to the calyx.

The movement of the C-arm is a helpful tool in this situation as described by Gökce Mİ et al. (10). We propose a geometrical model trying to explain this technique according to the position of the patient and the image intensifier.

II. FLUOROSCOPY PRINCIPLE

The discovery of X-rays was performed by Röntgen in 1895 and the first use of X-rays in urology was attempted by Wickbom in 1954 (11).

The medical use is based on the modification of the energy of the X-ray beam after crossing the human body.

As an X-ray beam passes through the body, the body tissues and bones absorb the beam in varying amounts depending on its density. The output is picked up on a sensor placed on the opposite side of the beam which transforms radiation into image (1).

This image is the projection of 3D radiopaque structures in a flat 2D black and white spectrum.

The principle of urography consists of the injection of the iodine contrast product either through an external ureteral stent, placed endoscopically in the renal cavities, or directly by needle puncture of the excretory system.

The contrast product submerges the excretory system. The X-ray exposure delineates the pyelocalicial tree as a biplanar projected image.

The typical fluoroscopy system used in urology is composed of 4 principal components (FIG1):

A. *The X-ray generator*

Using the emission of electrons by the heated cathode. The collision of electrons with anode produces X-rays.

The generator is placed underneath the operating table to limit radiation exposure.

Collimation, which means focusing X-rays on the targeted area, is regulated by the user interface.

B. *The image detector and intensifier*

It collects the X-ray beam that passed through the patient body.

It performs amplification and transformation of X-rays into light. The incident X-ray distribution is converted through 4 physical steps to the ultimate electronic signal.

The X-ray generator and the image intensifier are connected by a mobile metallic C-arm. Which allowed the maneuver ability and the adjustment of the position of the generator in different plans: anteroposterior, mediolateral, and craniocaudal, depending on the position of the operating table and the targeted area of the body.

C. *The user interface*

It allows through an on-board computer to control the technical aspects of the machine (collimation, dose, movement of C-arm, orientation of the image, contrast, ...), treats the image provided by the image intensifier and transmits it to the screen.

D. *The display*

It visualizes fluoroscopy view into 2D images.

a) *How does the movement of the C-arm change the fluoroscopy image ?*

The image on the screen depends mathematically on the position of the C-arm according to the position of the patient body. Each movement of the C-arm causes a rotation or translation of the image.

Any position of the C-arm induces an intersection of the X-ray beam with the patient's body in a given region and with a very precise angulation, which defines the final image on the screen.

What confuses the observer, in this case, is surely the change in orientation of the image.

To simplify the explanation, we present different positions of the C-arm with their impact on the orientation of the image on the screen (FIG 2, FIG 3, FIG 4, FIG 5, FIG 6).

III. DIFFERENT MANEUVERS OF C-ARM

The manipulation of the C-armis based on the basic principle of radiology: two views are necessary for localization.

The first image on the position of 0ºallows the adjustment of the needle in 2 plans : craniocaudal and lateromedial. But itdoes notin form about the position of the needle in the anteroposterior plane. Although in position 0º, the tip of the needle appears in contact with the fornix of the calyx, it does not mean that it is true because all parallelline to the direction of the X-ray beam passing by the tip of the calyxis projected on one single dot on the screen. The movement of the image intensifier by 30º or more in different plans delineates the position of the needle anteroposteriorly by demonstrating a translation of the position of the needle on the screen. We will explain the direction of the displacement of the needle corresponding to each movement of the C-arm. But in practice, the choice of one direction of the movement of the C-arm is suffisent.

1. How does the image move when the image intensifier moves toward the surgeon by 30º ?

If the needle is anterior to the calyx (red needle) in position 0º, it moves on the screen deeply into the calyx.

If the needle is posterior to the calyx (green needle), it goes away from the calyx.
(FIG 7, FIG 8)

2. How doesthe image move when the image intensifier move far from the surgeon by 30º ?

If the needle is anterior to the calyx (red needle), it goes away from the calyx
If the needle is posterior to the calyx (green needle), it moves into the calyx.
(FIG 9, FIG 10)

3. How does the image move when the image intensifier move toward the head of the patient by 30º ?
If the needle is anterior to the calyx (red needle), it goes below the calyx.
If the needle is posterior to the calyx (green needle), it moves above the calyx.
(FIG 11, FIG 12)

4. How does the image move when the image intensifier move toward the feet of the patient by 30o ?
If the needle is anterior to the calyx (red needle), it moves above the calyx.
If the needle is posterior to the calyx (green needle), it moves below the calyx.
(FIG 13, FIG 14).

IV. CONCLUSION

The comprehension of the impact of C-arm movements on the screen imageis an essential step to perform PCNL. The interpretation of the fluoroscopic view is based on geometrical rules easy to understand.

V. CAPTIONS

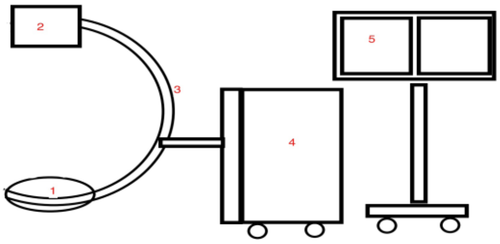

Fig. 1: Components of the fluoroscope.
1 : X-ray generator, 2 : image intensifier, 3 : C- arm, 4 : user inetrface, 5 : screen display.

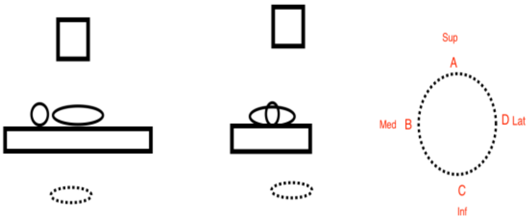

Fig. 2: the orientation of the fluoroscopic view in position 0 with the targeted area on the right side if supine position, or left side if prone position.

Sup : superior, inf : inferior, med ; medial, lat : lateral.

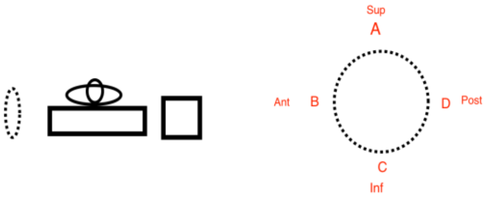

Fig. 3: rotation of the C-arm in the axial plane towards the lateralside.
Ant : anterior, post : posterior.

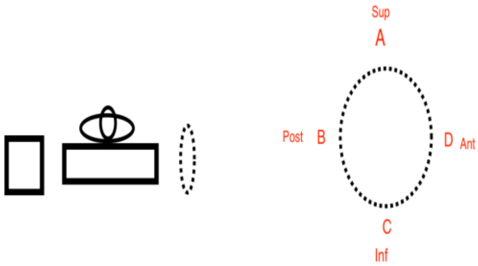

Fig. 4: rotation the C-arm in the axial plane towards the medial side.

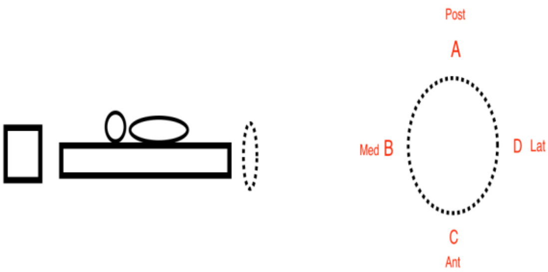

Fig 5. : rotation of the C-arm in the sagittal plane towards the head of the patient.

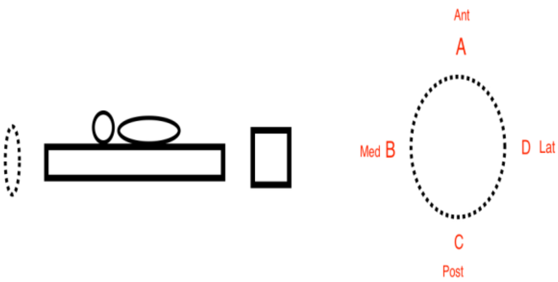

Fig 6. : rotation of the C-arm in the sagittal plane towards the feet of the patient.

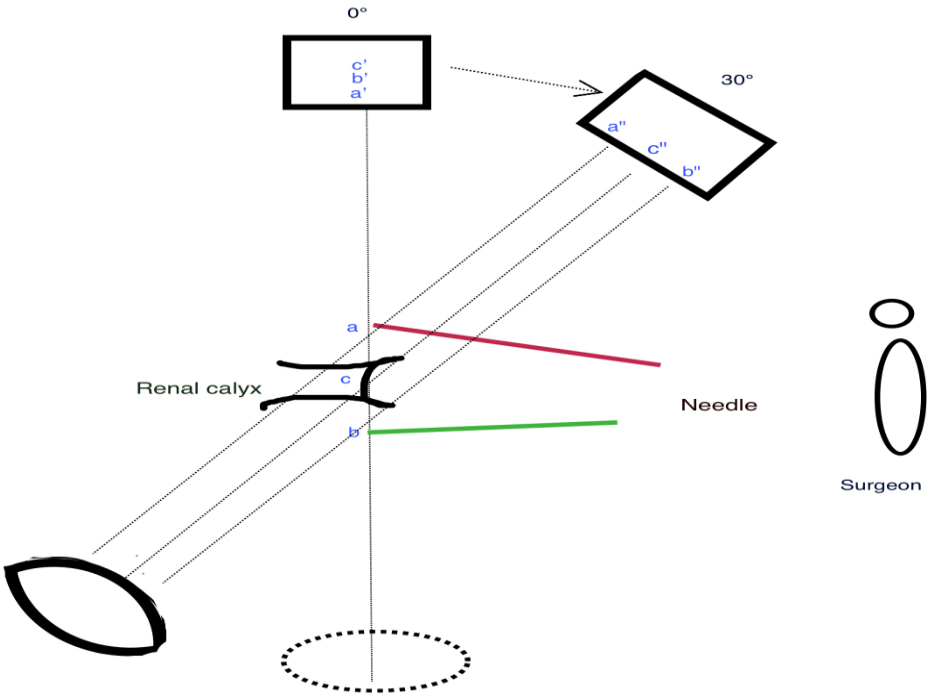

Fig. 7 : movement of the C-arm towards the surgeon by 30°. a : the tip of the redneedlewhichisanterior to the calyx.
b : the tip of the green needlewhichisposterior. c : the tip of the targetedcalyx.
a', b', c' are respectively the projections of a,b, and c on the fluoroscopicview in 0°.

a'', b'', c'' are respectively the projection of a,b, and c on the fluoroscopic view in 30°.

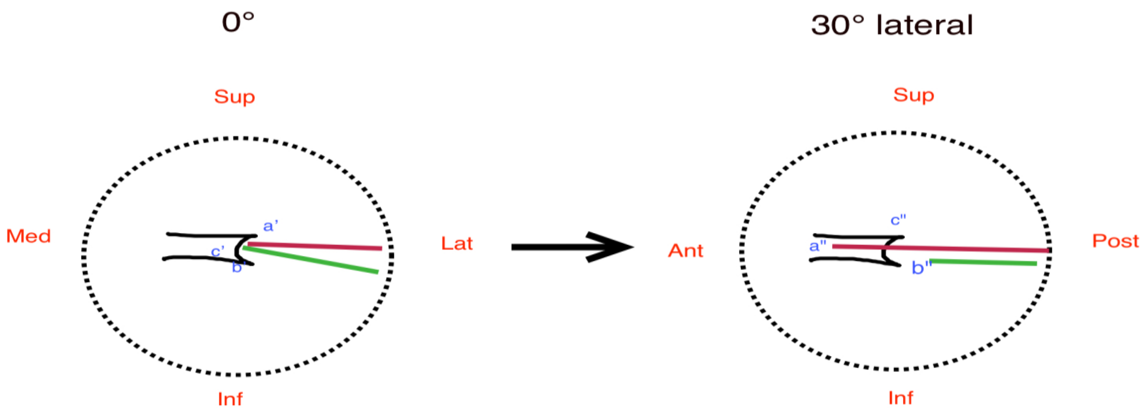

Fig. 8 : by changing the position of the C-arm towards the surgeon, the anterior needle moves deeply into the calyx, and the posterior needle migrates far from the calyx.

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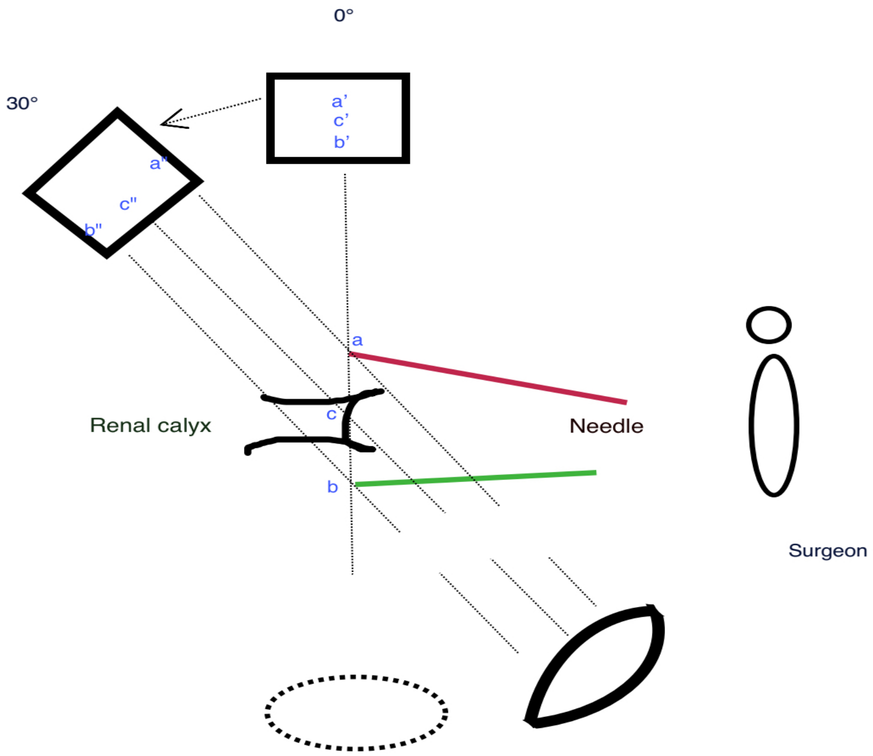

Fig. 9 : movement of the C-arm far from the surgeon by 30°.

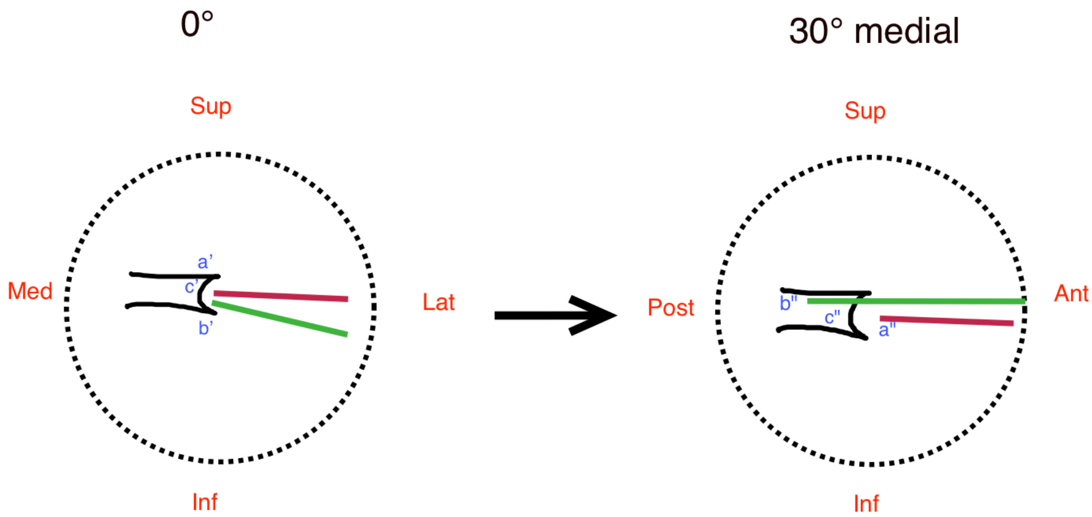

Fig. 10 : by changing the position of the c arm far from the surgeon, the anterior needle moves far from the calyx, and the posterior needle goes deeply into the calyx.

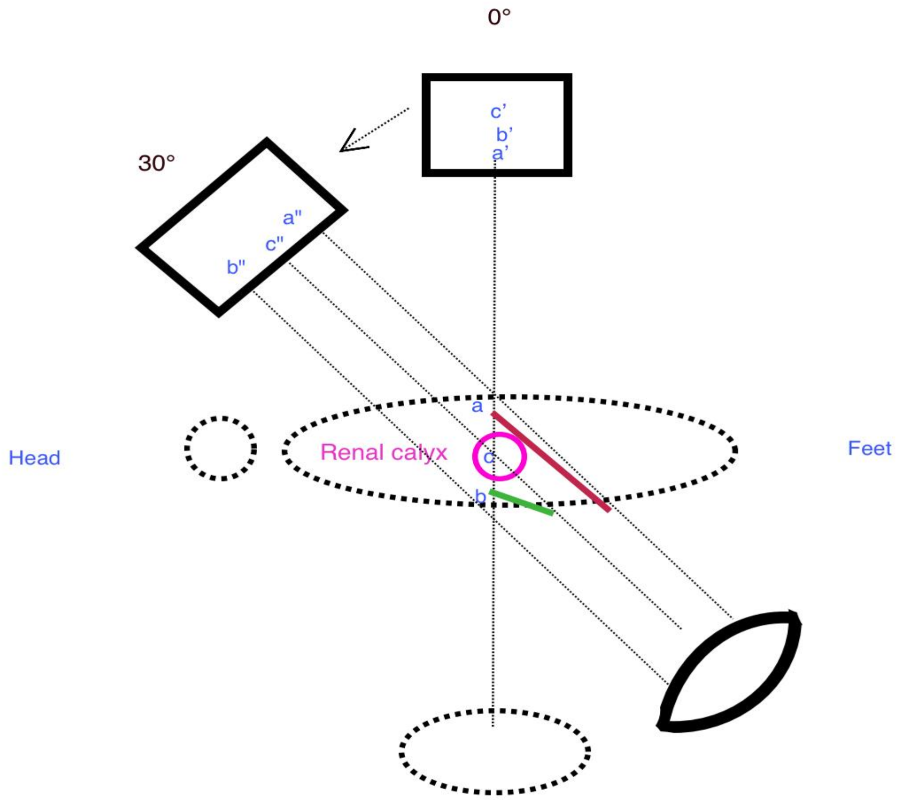

Fig. 11 : movement of the C-arm towards the head of the patient by 30°.

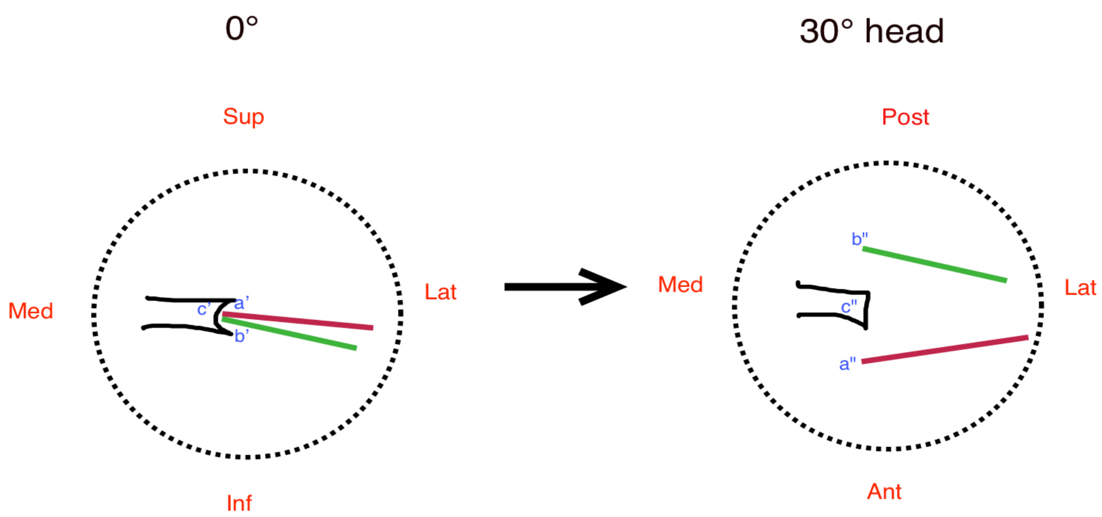

Fig. 12 : by changing the position of the c arm towards the head of the patient, the anterior needle moves below the calyx, and the posterior needle moves above the calyx.

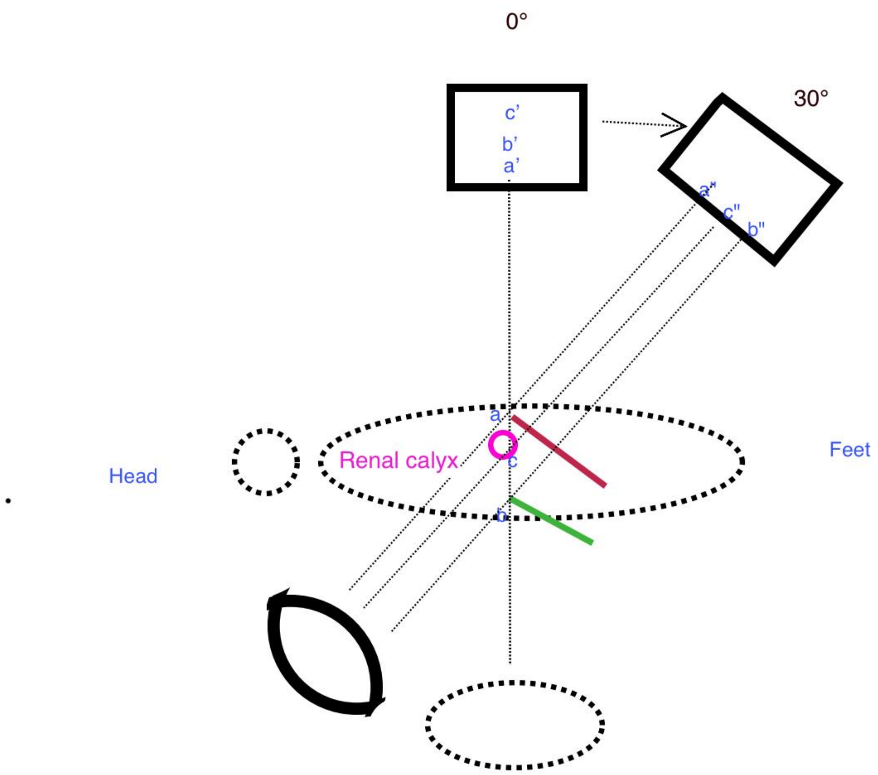

Fig. 13 : movement of the C-arm towards the feet of the patient by 30º.

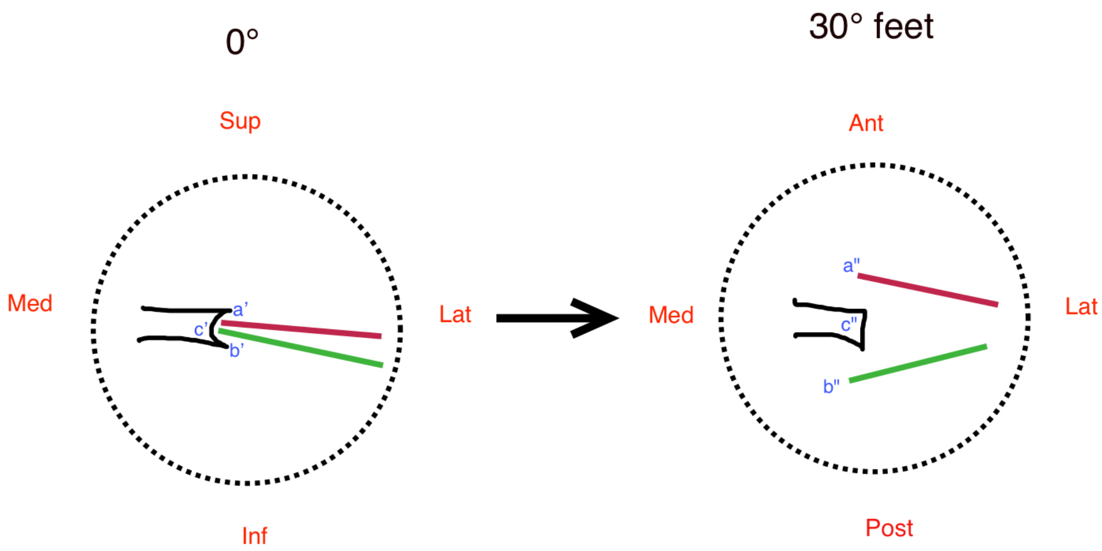

Fig. 14 : By changing the position of the c arm towards the head of the patient, the anterior needle moves above the calyx, and the posterior needle moves below the calyx.

DECLARATION OF COMPETING INTEREST

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence.

CONTRIBUTIONS

All authors have aprticipated to the design, the writing and the editing of the article.

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