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# MicroBox White light PCNL puncture trainer

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***Abstract :***
***Aim :*** *To create simplest PCNL puncture trainer & understand principles of puncture PCNL*
***Methods /Design:*** *Two Transparent plastic boxes reformed to upper deck made of lids 3 cms apart & lower deck with bottoms glued 3cms apart with side slit. Keyboard flash LED light is moved through slit in lower deck with change in position varying 0-20$^0$ craniocaudal as well as lateromedial. Lids are hollowed like a window frame. White paper& transparent polythene sheet is taultly fixed by closing upper& lower lids which are adhered.PCS is made of clear straw with ends closed with opsite The light facing upwards below the straw in alignment gives 0$^o$ as light moves out the angulation increase to 20$^0$& similarly when light source is moved caudally (towards bladder ).Puncture is done with modified spinal needle. Transparent Polythene sheet gives haptic feed back & stabilise the needle in position during puncture. White paper capture shadow & is seen directly for image interpretation & puncture . Principles of Triangulation Method is use for puncture simulating prone PCNL .*

***Observations :***
*1.**Calyx orientation** is **identified by rotation 0- 20$^0$ either craniocaudal or mediolateral .When tip of calyx moves away opposite to the direction of light source the calyx is downward facing and When tip of calyx moves along the same direction of light source the calyx is upward facing***
*2.**Superficial or deep** : On 0 -20$^0$ Mediolateral Rotation When needle is fairly below calyx (**deep**) the gap between needle tip & calyx tip widens apart & needle shortens moving laterally immediately **opposite to the direction of light** (within few degrees). When needle is fairly above (**superficial** )the calyx the gap between the needle tip & calyx tip shortens immediately& needle overshoots calyx (appears to move towards pelvis in the **same direction of light** ). When calyx is punctured properly both 0 & 20$^o$ images are congruent with needle inside. On caudal 10$^o$ rotation (towards bladder), needle turns cephalad wrt calyx long axis (**opposite direction of light ) when it is deeper** to calyx &caudal if **superficial** (**same direction of light ).***
*3.A medial drift of calyx & displacement of PCS due to **calyx indentation** of puncturing needle aid in accuracy of puncture .*
***Results:*** *The calyx filled with Ultravist contrast &sealed to obtain images under c arm. ImageJ analysis with same fixed reference points in ROI in both systems showed 97.3% SD 0.7 (n = 20) matching after adjusting magnifgication.*
***Conclusion :*** *This inexpensive, simple,portable model with reasonable haptics can be used for dry lab training for PCNL puncture.*

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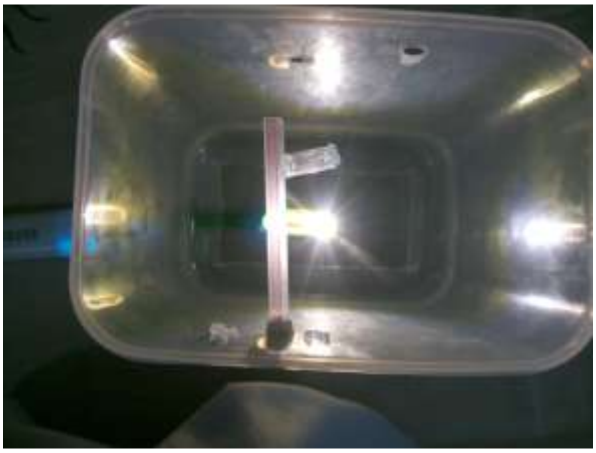
## I. Introduction

Simpler costeffective Models for PCNl simulation has been made before. Which includes (vegetable model) model by krishnamoorthy et al and Chinese glove model by Lezrek et al for PCNL .Here we attempt to make a portable box trainer with white light and that uses a designed calyceal framework compatable for white light. Different views of Microbox puncture trainer is shown below with its making and its components .



## II. Methods /Design

Transparent plasatic box ( 2 no: each with 20x 15 x 20 cms .One of the box is sliced horizontally at the level of 3 cms from the lid above and below at 2 cms above the base loaf. This makes two cups one with the lid and the other with the bottom after cutting form the peripheral part of the box and the central remaining part is discarded. The air tight lids are used for construction of upper deck such that the lids are placed superiorly(cup with lid glued above the lid of the intact plastic box) in 2 berths with a gap of 4 cms .

The bottom of the intact plastic container is covered with the cup that has the base of other plastic container.Thus bases are glued together with a gap of 2 cms forming lower deck inside which the light source can move in and out like a CD in a drive through a side slit . The overall dimesions of the box now are 25 cms x 15 x 20 cm. LED flash light is inserted facing upwards. The PCS is made of transparent straw(straw inserted through the hole in the side wall of plastic container) which is 3 cms from transparent polythene sheet and 11 cms depth from level of white paper .Movement of mobile LED light with change in position varying from 0 to 20 degrees cranio caudal as well as lateral to medial . With respect to straw.The lids are fenestrated in the central region like a window frame with placement of white paper and transparent polythene sheet like a screen in the upper and lower lids that form the superior deck. The central light facing upwards below the straw gives zero degree shadows is in alignment with PCS and as the light source moves out the angulation of the light rays increase towards 20 degrees and Similarly when the light source is moved caudally (towards the bladder ).The straw can be angulated at the desired depth and moved in or out. Puncture is made with modified spinal needle telescoped in to cannula needle . Transparent polythene sheet is used for haptic feed back to stabilise the needle during puncture as thin white paper alone is cannot hold the needle and give sufficient haptic.

Single (only) light LED light source avoids multiple shadows..

Make of Calyx

Making of The Microbox in pictures.


Calyx end can be made with a piece of cellotape ,opsite ,or sutured polythene sheet .Also glass ampoule is used as calyx with opsite attached at the end. The calyceal indendation can be demonstrated with the help of pincushion effect over the end of calyces. Glass ampoules acts like a lens and produce distortion of needle images within the calyx.

Make of Needle 23G. 15 cms spinal needle with blunt end telescoped in to cut end of hollow 16G cannula needle.White paper is usedfor shadow capture and is seen directly for image interpretation and puncture . The hollow tip of the straw or custom made tubular calyx with OHP transparent paper and straw bands is covered at the end by by cellotape or thin strip of opsite to get haptic feed back and calyceal movement at puncture.The spinal needle is less traumatic and polythene sheets & paper last for multiple uses. Fixing them by closing with lid keeps them taut .Instead of mobile flash light a keyboard flash light with single LED as light source is connected to power bank can also be used. Principles of Triangulation Method is used .Initial puncture in longitudinal axis in zero degrees. Depth perception made out in 0- 20 degrees while Advancement of needle is made in zero degrees.By the law of traingles and inverse tan theta measurements the effective mediolateral and carnicaudal rotations are calculated and gauged based on the distance as the LED light is moved from the zero degree position .When it is c arm the light takes the path of the curvature while here it takes the base of the triangle formed by calyx as apex and Perpendicular drawn from above meets the base (zero degree position for LED light) .As the degrees advance along the base of triangle the light lies little outside the curvature of c arm if it would have been there.The LED light should have been in a little elevated position to compensate for the curvature of c arm..Hence that farther parts of calyx tend to have a smaller dimensions as the light is slightly farther away.As calyx are smaller it tend to behave like a Similar effects should apply relatively to the needle with more of physics involved. Also the image is captured by flat paper unlike coaxial equidistant image capture in c arm.But again the light rays in the trainer or even x rays are diminutively diverging . Even in the c arm the receiver is flat but follow the curvature .To get ideally tangential image capture the c arm receiver should have been a curved surface. The effect is like watching a movie from corner of cinema hall on the screen even if it is flat or curved still we are able to see the movie without realising the physics involved. For practical purposes grossly the images look similar subtle difference can be obseverd when compared and analysed with c arm images under magnification and image analysis . With the present configuration it is possible to obtain a optimum range effective of 0-10 degrees of cranicaudal rotation and 0-20 degrees of mediolateral without noticeable aberrations or distortions in the images.

## III. Observations

Calyx orientation is identified by rotation from 0- 20 degrees mediolateral .Upward facing calyx become shorter ,and downward facing calyx become longer .On caudal rotation of light (towards bladder) the calyx turns cephalic when it is downward facing and vice versa.

In 20 mediolateral M/L degrees the needle below the level of calyx (deeper) appears shorter and the one superficial to calyx appears overshooting before the puncture. When needle is fairly below calyx the gap between the needle tip and calyx tip widens apart and needle shortens moving laterally immediately ( within few degrees). When needle is fairly above (superficial ) the calyx the gap between the needle tip and calyx tip shortens immediately and needle overshoots calyx relatively moving medially .
The changes are remarkable when the needle is farther from the calyx. As the needle approaches the calyx tip or gets closer to nearby region the changes are less dramatic and equivocal. If it is in alignnment and just superficial to the calyx there is a delayed overshooting and when the needle is at inferior part of calyx tip or just lower to calyx there is a delayed (within greater degrees) widening .

When the calyx is punctured exactly at the center of calyx and is inside both zero and 20 degree images are congruent with needle remaining at the center inside calyx.when the needle is actually ouside the calyx but appears within in zero degrees, when there is mediolateral rotation the tip of the needle appears to go towards the pelvis .when it is actually deeper the tip of the needle appears to go outside the calyx.

On caudal 10- 20 degree rotation of light source , the needle becomes cephalad with respect to long axis of calyx when its is deeper to calyx and caudal when it is superficial (same direction of movement of light ).The farther the target from the needle the more dramatic are the events and when closer to the target the changes are sparse and slow as in case of just superficial or deep

Zero

20 degree

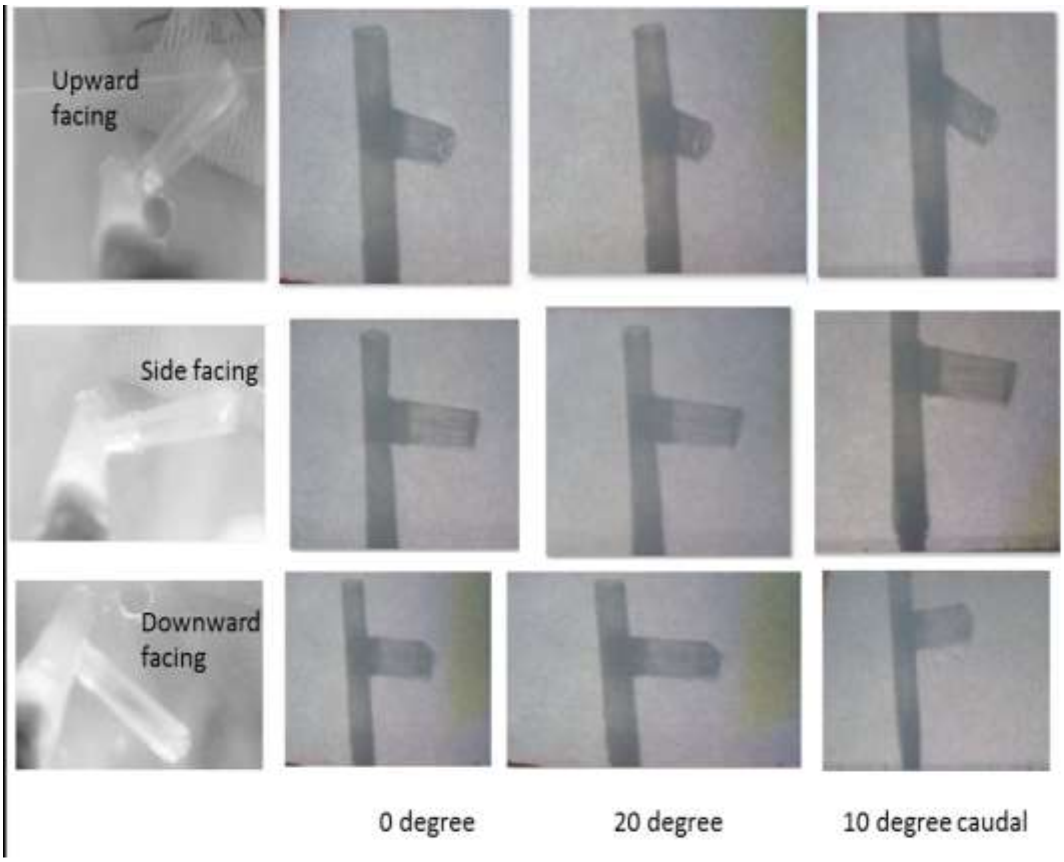
10 caudal

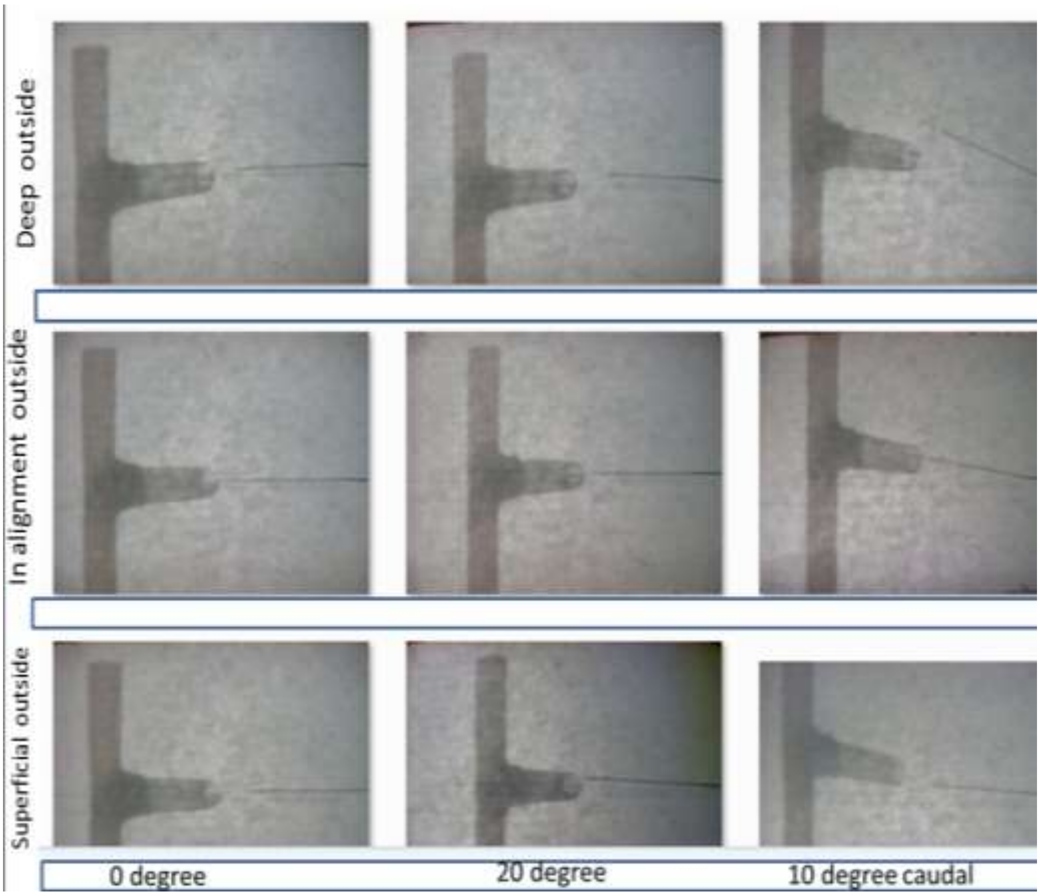
positions. When the calyx is about to be punctured perfectly the long axis of the calyx and needle remains almost in line in all caudal rotation. when needle surpasses beyond calyx tip the orientation can again be checked and confirmed.

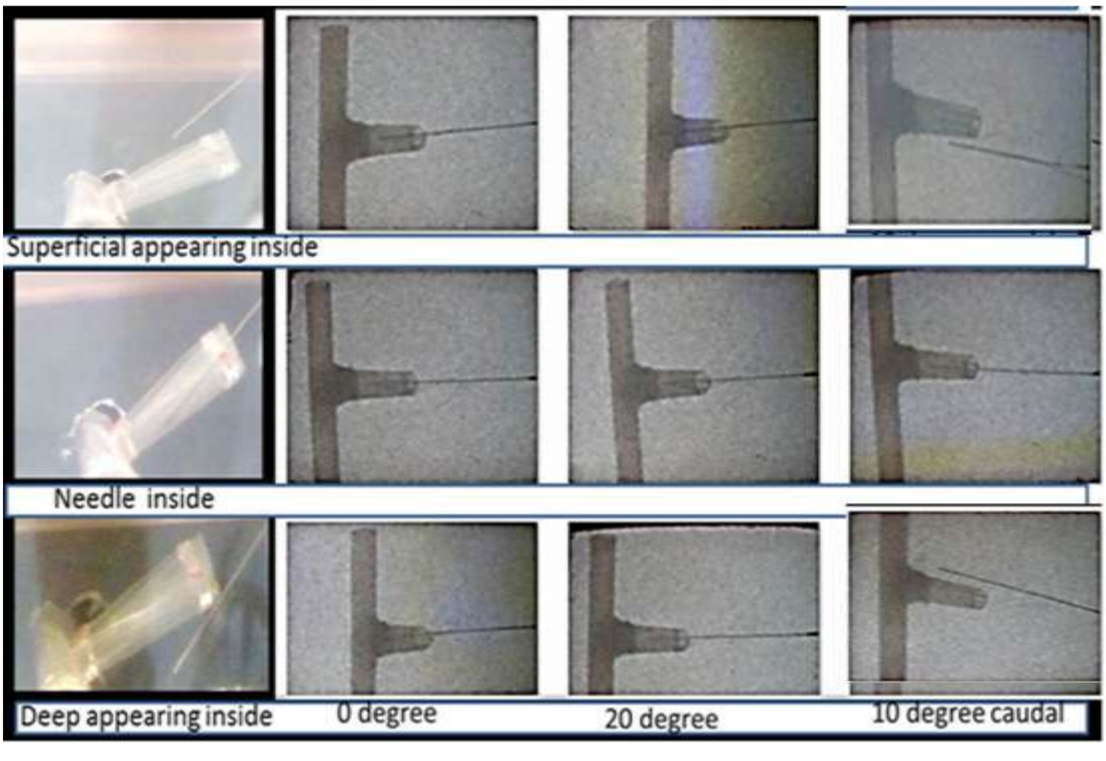
***Summary :***

***The change in position of needle with respect to axis of calyx in two different angles enables to interpret whether it is superficial or deep to calyx. For this Initial calyx axis is aligned with needle at zero degrees and changes in position of needle with respect to long axis of calyx is observed in mediolateral or craniocaudal rotations. 1.When tip of the needle moves towards the direction of light in the images the needle lies superficial to calyx .2.When tip of the needle moves away opposite to the direction of light in the images the needle lies deep to calyx Both these are applicable in any rotations .3 When the needle is in alignment or perfectly inside the calyx there is no relative changes in the images in any rotations .This Triangulation can be achieved and checked prior to the puncture of the calyx .***

At extreme angles of superior and inferior calyx the medial lateral axis turns its orientation towards caudal cranial axis .For study purposes calyx facing perpendicular to ureter axis is taken for demonstration purposes. when the tip of the calyx is being punctured , initially there is a small medial drift of the calyx and displacement of the pelvicalyceal system produced by the indentation of the puncturing needle which gives haptic feed back and is an important adjunct factor that aid in the accuracy of the puncture .




Deep outside
In alignment outside
Superficial outside
0 degree
20 degree
10 degree caudal


Superficial appearing inside
Needle inside
Deep appearing inside
0 degree
20 degree
10 degree caudal

## IV. Results

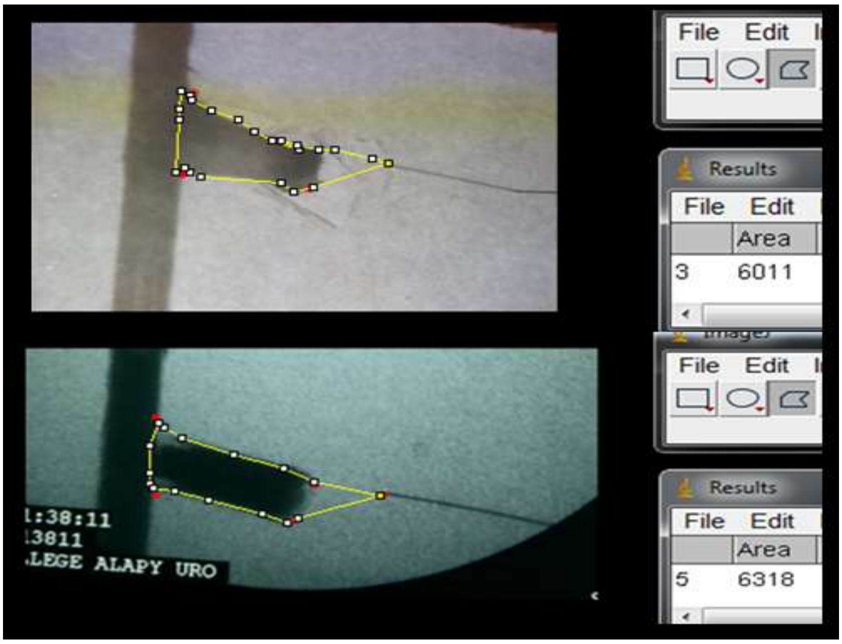
The self making process and interpretation of the images with the above relevant observations is conducive. Comparison of images of PCS under C arm and microbox trainer were done .The PCS was filled with Ultravist contrast and sealed to obtain images under c arm .Image J analysis with same fixed reference points and area measurement was done in the region of interest in both the systems . Image J analysis of calyces in different positions with polygonal selection showed 97.3 % SD 0.7 (n = 20) matching of the area of interest .The cost of single device is estimated within 700 INR.

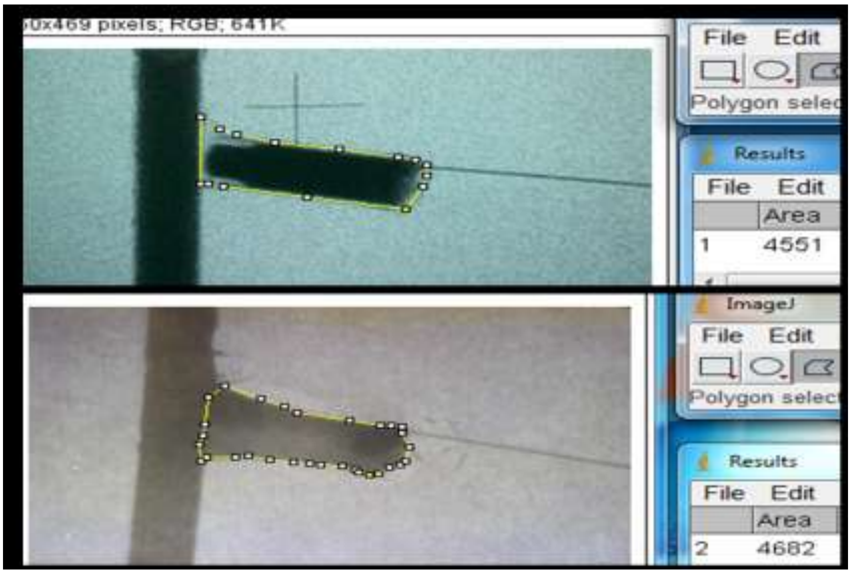
Assessment validation (n=8) regarding the following among the users (Median).

- Understanding Triangulation - fully satisfied
- Demonstration of calyx orientation - satisfactory
- Demonstration of calyx indendation- fully satisfied
- Haptics – Reasonable .
- Overall comparision with c arm image – Grossly similar.
- Enables understanding and Interpretation of c arm images in PCNL- satisfactory.

***Comparison of simultaneous C arm and microbox images*** .

**Image J analysis** of similar reference points in both images are taken and analysed .The percentage of area match is calculated. Example 1,2 below..6011/6318=95.14 percent.
Example 2. 4551/4682 =97.2 %




## V. Conclusion

It is inexpensive ,Simple ,portable , minion, handy model which helps to understand the principles of calyx orientation and its relationship with needle between zero and 30 degrees for prone PCNL .The images in c arm and the microbox are highly congruent and virtually the same hence can be used for dry lab training for PCNL puncture. Knowledge of the procedure is a crucial factor .We hope this simple self make device will help to Understand the principles involved in calyceal puncture ,reduce fluoroscopy time .
Shorten learning curve and reduce the complications in the training.

## References

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**Video 2** **https://youtu.be/axD0-SklFMw**
**Video 3** **https://youtu.be/XAXvcciwJJU**
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