Simple method improving the accuracy of puncture in anterior ventricular access of EVD--based on radiological data of Chinese adults

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Research Article

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Abstract

**Background:** In our clinical work, we sometimes find that the classic technique of anterior ventricular access of EVD is not accurate, so we use simple method to improve its accuracy.

**Methods:** Using a standard axial computed tomography scan of cranium on viewing system (any slice and any distance between two points can be measured easily when we needed), we locate some projections and other sites that we need on topogram(scanogram), then locate them on patients' scalp. Combining their locations above, we want to verify the shortcoming of classic technique of anterior ventricular access of EVD and to improve it.

**Results:** The study demonstrates that there are some shortcomings in the classic technique of anterior ventricular access of EVD, we can get a more accurate result via a simple method in our practice.

**Conclusions:** Using a simple method, we can improve the accuracy of the technique of anterior ventricular access of EVD.

1 Introduction

In our neurosurgical clinical works, external ventricular drain (EVD) is usually used. Among these punctures of different parts of lateral ventricles, the frontal horns of lateral ventricles are most often selected as the target of puncture. The classic technique had been detailed in many reference articles of neurosurgery, like Kocher's point (11cm superior and posterior to the nasion, or 1-2cm anterior to the coronal suture at the midline, and 3cm lateral to the midline), and puncture direction of the catheter should be aimed at the point where an angle that is perpendicular to the intersection of lines drawn from the ipsilateral medial canthus and between the bilateral external auditory meatus [1]. Following the procedure above, the tip of the catheter should be placed in the frontal horns of lateral ventricles near the foramen of Monro.

But in our EVD practice, we execute the technique and procedure strictly. But our catheter tip usually reaches the bodies of lateral ventricles, and sometimes it goes through very long length in brain along the lateral wall of ventricle closely before it enters into the ventricle at last. So we thought to get the locations of the mid-point of the frontal horns of lateral ventricles (AHLV) by simple method of projections (bilateral, adjacent to pterion point on patient's head; and bilateral, on both sides of the midline of patient's forehead), and use an iron bar make the puncture more accurate in our practice. Through a few year's practices and thinking, now we get a good result via this simple method.

2 Materials and methods

2.1 Patient population and data collection
From June 2022 to May 2023, 20 Chinese adult patients (10 male, 10 female, age 55±13.4 years) were admitted to our study, and all patients complete a standard axial computed tomography scan of cranium in our hospital, in order to their data can be used on viewing system by us, for any slice, including the slice's location on topogram (scanogram) can be demonstrated, and any distance between two points can be measured easily on this viewing system when we needed. All CT images are scanning at a thickness of 6mm, and each patient's topogram (scanogram) is intact.

2.2 Location of the lateral projections of the mid-points of the AHLV and other structure on topogram (scanogram)

When we view routine a standard CT scanning of cranium on viewing system, in which any slice and any distance between two points can be measured easily when we needed, and each topogram (scanogram) is a standard X-ray lateral view of head. We always can find a slice on which the AHLV can be shown more distinctly from them. The mid-points of the AHLV are very easy confirmed on the slice that being selected above, then using simple measurement of the distance between the anterior external surface of frontal bone and the mid-point of AHLV, the lateral projection of the mid-point of the AHLV can easily located on the topogram (scanogram) (Fig. 1A). Using the same method, We also can locate the coronary suture on midline of head and the projections of bilateral external auditory meatus on the topogram (scanogram) too (Fig. 1B-E).

If we want to locate the lateral projections of the mid-point of the AHLV on the head. We can draw a linear (linear A) through bilateral mid-point of the AHLV on the slice that being selected, and the sites where the linear cross the scalp surface are the lateral projections of the mid-point of the AHLV (Fig. 2). The projections cannot be confirmed on scalp surface of head directly. But by the help of cranial bone structure nearby, we can locate it.

If we carefully look at the CT slice above, we always find that there are always apparent bone grooves of lateral surface just anterior (or posterior) to the projections slightly. We can find and mark this bone grooves after the slice being selected above is marked out on the surface of head, then we will gain a linear (linear B) through bilateral bone grooves (Fig. 2). The distance between linear A and linear B on scalp can be measured on the CT slice, and with the measurement above, we can locate the projections on the surface of head easily after the bone grooves are confirmed. Coronary suture of bilateral surface of head also lies nearby, but its location is difficult on CT image or on the surface of head.

So we can first mark out the slice on the scalp surface of patient's head with a mark pen, then we can locate and mark the bone grooves on the marked line. After that, according to distance measurement of CT, the projection of lateral view of the mid-points of the AHLV are located on the marked line of patient's scalp surface, then we can mark the contralateral point.

There is another method following our experience to locating the projection of lateral view of the mid-point of the AHLV. We can mark out the linear from the external auditory meatus to the mid-point of eyebrow arch on CT topogram (scanogram), the linear is parallel with the line of anterior floor of skull, and
the distance between two lines often is 1cm or 1.5cm (Fig. 3). The Paine point often being used in neurosurgical operation lies 2.5cm above the line of anterior floor of skull [2], so the distance between the Paine points and the linear from the external auditory meatus to the mid-point of eyebrow arch often is 3.5cm to 4cm. Our data of this distance is male 3.7±0.3, female 3.5±0.3. The anterior-posterior locations of projections are also confirmed indirectly from the groove’s locations as before.

2.3 Coronary plane of puncturing being confirmed

After the projections of lateral view of the mid-points of the AHLV being located, we mark the bilateral bur hole point, like the Kocher point. As said above, we often locate the Kocher point as 1-2cm anterior to the coronal suture at the midline and this method is easily done in practice. Then a curve line can be drawn through the four points, these makes up a coronary plane and the trajectories of catheter are all in it. As a part of the curve line, a linear is drawn between the projection and the Kocher point, but it’s end often reach the cross-point that the coronary suture and the sagittal suture on median line (as Fig. 4A-B). So we can obtain a rough direction (red line, not green line) of the Kocher point to the mid-point of the AHLV on CT topogram(scanogram) (Fig. 5).

Two methods above can verify mutually, in order to finally locate the projections better.

Considering all possibilities of burr-hole point as the location of the Kocher’s point described by different authors, some linear can be drawn on CT topogram(scanogram) as the possible puncturing trajectories. The trajectories orient to the cross-point of sideburns and zygomatic arch, but none of them orients to the external auditory meatus (Fig. 5).

If you bur hole on the point which lies 7-8cm superior and posterior to the nasion or 5-6cm anterior to the coronal suture at the midline, the trajectory just right orient to the external auditory meatus (Fig. 6A-B). The point often lies on the anterior hairline of head. This result also can be verified on patient’s head.

2.4 The projection of AP view of the mid-point of the AHLV bilateral being located

We can also draw a linear (linear D) from projections of the mid-point of the AHLV to the patient's face the on CT topogram(scanogram), to obtain the next plane which is perpendicular to the coronary plane of puncturing. The cross-point between the plane which is perpendicular to the coronary plane of puncturing and the mid-line of the face can be located, and the point can be marked on the face easily (usually 2cm superior to the arcus superciliaris).

Because the cross-point often lies on forehead where the next plane is perpendicular to the midline of head on surface of scalp, so there is not a deviation like drawing a linear from the lateral projection to the Kocher point.

In our experiences, if the point of burr hole lies 1.5cm anterior to the coronal suture at the midline, the point between bilateral projection of AP view of the mid-point of the AHLV is usually located on 2cm
superior and posterior to the nasion, just above the bone groove superior to the arcus suprachiasmatics. Certainly, you can draw a line on scalp which is perpendicular to the coronary plane of puncture mentioned above, and the cross-point of the line and the midline of scalp on head can be marked too. The A-P projections of the mid-points of the AHLV lies on both side of the cross-point, and the distance lateral to the midline can be marked on forehead based on CT measurement.

3 Results

3.1 Projections make the puncture of the AHLV simple and easily

Via the bilateral projection of lateral view of the mid-point of the AHLV being located on the head and the point of burr hole being confirmed, we build a coronary plane of puncturing which containing the four points above. Then we build the next plane which is perpendicular to the coronary plane of puncturing, and the next plane containing the linear A. Then the crossing point between the next plane and the midline of the forehead can be located and marked out. Based on the particular CT slice, the distance between the mid-point of the AHLV and the mid-line of the brain can be measured, and the distance can be marked on both side of the cross-point above. So we can mark the bilateral projection of A-P view of the mid-point of the AHLV on skin of the forehead. The sites being marked on both side of the cross-point should be the projections of A-P view of the mid-point of the AHLV based the point of burr hole on skull.

Based on the four projections (2 on lateral view and 2 on A-P view) being located precisely, we can get a good result from the ventricular puncture through the Kocher point. The technique becomes more precisely, simpler and easily.

4 Discussion

4.1 Using the four projections of the mid-point of frontal horns of lateral ventricles, we have improved our accuracy in anterior access of lateral ventricles.

We revise the trajectory of puncture more anteriorly, and puncture direction of the catheter isn't aimed at the line drawn between the bilateral external auditory meatus but the bilateral cross-point of sidebumps and zygomatic arch (about 4cm anterior to the external auditory meatus on the zygomatic arch) (as Fig. 4A). Certainly, it is more accuracy when puncture direction of the catheter is aimed at the line drawn between bilateral projection of lateral view of the mid-point of the AHLV.

At the beginning, we often select the point which is 3cm lateral to midline on scalp to burr hole (on axial CT measurement, the distance is about 2cm horizontally) strictly according the Kocher point, but subsequently we find more serious cerebral edema around the catheter, probably because the trajectory of catheter enters the superior frontal sulcus or the superior frontal gyrus from the middle frontal gyrus. Based on our experience, there will be more intracerebral hematoma incidence rate after operation, and
probably because you will meet more arachnoid granulations and bridging veins (Mittenzweig veins) when the point of burring hole is closer to midline. After realizing the two shortcomings above, so we move the points of burring hole slight laterally, which is 3.5cm lateral to midline on scalp (about 2 horizontal finger width), and on axial CT measurement the distance is about 2.5cm horizontally. The point which we select do not coincide with the Kocher point completely but basically.

Deviation occurs in the puncture of anterior horn of lateral ventricle according to Kocher's method. If we do puncture orienting the ipsilateral medial canthus, our catheter often go through very long length in brain closely along the lateral wall of ventricle before it enters into the ventricle at last. Then based on our measurement and experiences, we select the midpoint between bilateral medial canthus as the aim of puncture, and the catheter enters the lateral ventricle perfectly. Laterally the correct angle puncture is verified by projections of AHLV of A-P view, and the bilateral distance which the projections of the AHLV of A-P view lateral to the midline on skin of forehead is measured on axial CT scanning respectively.

4.2 If you want to do a perfect puncture of the AHLV, following the procedure below:

4.2.1 Mark the midline on scalp from nasion to the coronal suture;

4.2.2 Mark the bilateral point of bur hole. We usually select the point which is 3.5mm (about 2 horizontal finger width) lateral to the midline, and 1.5cm (about 1 horizontal finger width) anterior to the coronal suture.

Note Base on experience, the anterior interhemispheric fissure usually lies on the site of the Kocher point with a deviation to right slightly (3-5mm lateral to the midline which we have marked), and we must notice to eliminate the deviation during operation.

4.2.3 Mark bilateral projections of the AHLV of lateral view on scalp, then mark bilateral projection of the AHLV of A-P view on skin of forehead. Draw a curve line connecting lateral projections and the points of bur hole bilateral, then the line connecting the bilateral point of bur hole, and the line circling a coronal plane which the trajectory of puncture lies in.

4.2.4 Bur hole on skull bone bilateral.

4.2.5 During the puncture, you will meet the condition in which you care for this and lose that because you need notice lateral projections and projections of A-P view at the same time. To avoid this awkward condition, you need a assistant's help. But if you don't have any assistant in operation, you can use the methods below:

A: a simple method to solving the .2 is placing the line connecting lateral projection and the point of bur hole horizontally, and you only need care the projections on forehead as the trajectory of puncture parallels to the floor;

B: another simple method is fixing a iron bar along the lateral portion of the line which is marked on scalp and forms the plane of puncture with the point of bur hole, and you only need put the catheter on the iron
bar, change the angle of puncture and penetrate the catheter aiming bilateral projection of A-P view of the mid-point of the AHLV on skin of forehead (Fig. 7A-B).

C: use method A and B both.

4.2.6 Direction of puncture should aim at the bilateral A-P projection of midpoint of the AHLV on skin of forehead. The location of the projections can be measured on the axial CT scanning when the midline is shifted.

4.2.7 We can select the midpoint between bilateral medial canthus as the aim of puncture, unless mark the bilateral A-P projections of mid-point of the AHLV on skin of forehead if their location is normal. Normal distance of the midpoint of the AHLV lateral to the midline is about 1-2cm.

4.2.8 If you must bur hole from which puncture the AHLV aiming the line between bilateral external auditory meatus, you should select the site 7-8cm superior and posterior to the nasion, and mark the projections of the midpoint of the AHLV of A-P view on both side of highest site of nasal bone, or aiming apex nasi if you bur hole 3.5cm lateral to the midline when location of the midpoint of the AHLV is normal. You can only use the method B to help you, because the trajectory being placed horizontally is difficult in this condition.

4.2.9 The length of catheter entering the brain which can reach the central point of the anterior horn of lateral ventricle cannot be measured, but based past experiences, it is not more than 6cm.

4.3 The data and experiences above are obtained from measurement of CT, and they also can be acquired from stereotactic system, neuronavigational system or surgical robot, but they are more complicated and more expensive.

4.4 The data and experiences above are obtained from Chinese adults, and whether they are suitable for other racial adults is uncertain. It needs more information of study as proof.

5 Conclusion

Based on radiological data and measurement on CT, via four projection's location and some simple method, we can make the anterior access of the EDV easier and more accurately.

Declarations

Ethical Approval

This study was performed in line with the principles of the Declaration of Helsinki. Approval was granted by the Ethics Committee of the Central People’s Hospital of Tengzhou.

Competing interests

The authors have no relevant financial or no-financial interests to disclose.

Authors' contributions
Dr. Yandang Sun contributed to the study conception and design. Material preparation, data collection and analysis were performed by all authors. The first draft of the manuscript was written by Dr. Dongyuan Wang and Dr. Yandang Sun commented on previous versions of the manuscript. All authors read and approved the final manuscript.

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Availability of data and materials

All datasets used in this article can be accessed by anyone if he/she requires them.

References


Figures
A Select a slice in which the anterior horns of lateral ventricles (AHLV) are shown more distinctly in a standard CT scanning of cranium on viewing system. Draw a linear through bilateral mid-point of the AHLV, then using simple measurement of the distance between the anterior external surface of frontal bone and the mid-point of AHLV, the lateral projection of the mid-point of the AHLV can easily located on the topogram (scanogram).

Figure 1
B-E Using the same method, we also can locate the coronary suture on midline of head and the projections of bilateral external auditory meatus on the topogram (scanogram) too. There is a slightly disparity between the projections of bilateral external auditory meatus, and we can use their average value.

Figure 2

A linear (linear A) is drawn through bilateral mid-point of the AHLV on the slice that being selected. The second linear (linear B) is drawn through bilateral bone groove on the slice. Measuring the distance between two linear on scalp on CT, and they are usually lesser than 5mm mostly (anterior to or posterior to) and overlapping sometimes. We can locate the projections of the mid-points of the AHLV on the surface of head easily after the bone grooves are confirmed.
Figure 3

Following our experience, another method to locating the projections of lateral view of the mid-point of the AHLV. We can mark out the linear from the external auditory meatus to the mid-point of eyebrow arch on CT topogram(scanogram), the linear is parallel with the line of anterior floor of skull, and the distance between two lines often is 1cm or 1.5cm. The measuring results on CT topogram(scanogram) are in conformity with classic location of Paine points. So the distance between the Paine points (also is the midpoints of AHLV) and the linears from the external auditory meatus to the mid-point of eyebrow arch often is 3.5cm to 4cm.
A-B Locating the projections of lateral view of the mid-point of the AHLV according Fig 3, then locating them on patient's scalp according the location relationship of the projections of lateral view of the mid-point of the AHLV and bone grooves in Fig 2. Then a curve line can be drawn through the four points (bilateral Kocher point, bilateral projection of lateral view of the mid-point of the AHLV), these makes up a coronary plane and the trajectories of catheter are all in it. As a part of the curve line, a linear is drawn between the projection and the Kocher point, but it's one end often reach the bilateral cross-point of sidebumps and zygomatic arch(A), other end of it often reaches the cross-point that the coronary suture and the sagittal suture on median line(B).
Figure 5

Based on Fig 4B, we can obtain a rough direction (red line, not green line) of the Kocher point to the mid-point of the AHLV on CT topogram(scanogram). Other color lines demonstrate that if you burr hole on the Kocher point nearby, the trajectories orient to the cross-point of sidebums and zygomatic arch, but none of them orients to the external auditory meatus.
Figure 6

A-B Only you burr hole on the point which lies 7-8cm superior and posterior to the nasion or 5-6cm anterior to the coronal suture at the midline, the trajectory just right orient to the external auditory meatus.
Figure 7

A-B Fixing a iron bar along the lateral portion of the line which is marked on scalp and forms the plane of puncture with the point of bur hole, and you only need put the catheter on the iron bar, change the angle of puncture and penetrate the catheter aiming bilateral projection of A-P view of the mid-point of the AHLV on skin of forehead.