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COMPARISON OF ELLIPTIC EQUATION – ABC/2 WITH COMPUTER-ASSISTED SEMIAUTHOMATIC METHODS FOR MEASURING THE VOLUME OF INTRACEREBRAL HEMORRHAGE

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Hemorrhage volume, level of consciousness and ventricular extension and expansion of the hematoma are prognostic factors for clinical outcome of intracerebral hemorrhage (ICH). Volumetric measurement of ICH has an important clinical and prognostic meaning.

The aim of this study was to compare the methods which are being used to measure ICH volume: the ABC/2 method and semiautomated method with computer volumetric program.

Our study represents a retrospective analisys of 54 patients (61.11% male and 38.89% female patients with mean age 67.20±10.30 years) who underwent computed tomography (CT) scan of endocranium. Volumetric measurements were performed by ABC/2 method and computer semiautomated method with volumetric program on Advantage Windows 3D Workstation 4.1.

Mean value and standard deviation obtained by ABC/2 method were 41.98±35.47, while mean value and standard deviation obtained by computer semiautomated method with volumetric program were 52.12±45.61. There is a statistically significant difference between the values obtained by these two methods ($p=0.03$). The absolute difference was 10.14 cm^3. The values acquired by computer method were by 19.46% higher than those acquired by formula. There is a statstically strong positive correlation between these two methods ($r=0.852$, $p<0.05$).

Both methods are very useful in determining ICH volume. Our results show that values obtained by computer semiauthomatic method were by 19.46% higher than those obtained by the elliptic equation. Elliptic equation-ABC/2 method is better for measuring regular ICH shapes and fast orientation, while semiautomated computer method is more accurate and more selective. *Acta Medica Medianae 2015;54(3):34-38.*

Key words: *intracerebral hemorrhage,* computed tomography (CT)*, volumetric measurement*

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Introduction

Intracerebral hemorrhage (ICH) is an urgent neurolocigal and neurosurgical condition with potentially high mortality. The most common causes of ICH are hypertension, arteriovenous malformation, head trauma, tumors and aneurysms (1). The initial volume of the hematoma correlates with clinical outcome and is used as a guide for acute treatment and prognosis (2). Thirty-day mortality is 44%, with half of the deaths occuring in the acute phase, especially during the first 48 hours (3). There is no proven effective treatment as well as the ability to promptly determine the prognosis of the patient. The volume of hemorrhage, level of consciousness and existence of intraventricular expansion represent the prognostic factors for clinical outcome of ICH (4). Volumetric measurement of ICH has great clinical and prognostic significance (5).

Computed tomography (CT) is used as an imaging technique of choice in the diagnosis of intracerebral hemorrhage (6). ICH volume can be measured by several methods (7). The most common methods used for volumetric measurement of ICH are the method with the application of formula for the elliptic equation - ABC/2 method and computer semiautomatic method. Measurement with computer semiautomatic method is precise and

analyzes an image on computer program (computer-assisted image analysis). The method using the elliptic equation - ABC/2 is applied in order to measure rapidly the volume of acute parenchymal bleeding, it yields good results and may represent a powerful tool in predicting outcomes (7).

Aim

The aim of this study was to compare the methods that are being used for ICH volume measurement: the method with the application of formula for the elliptic equation - ABC/2 and semiautomatic method with computer volumetric program.

Material and methods

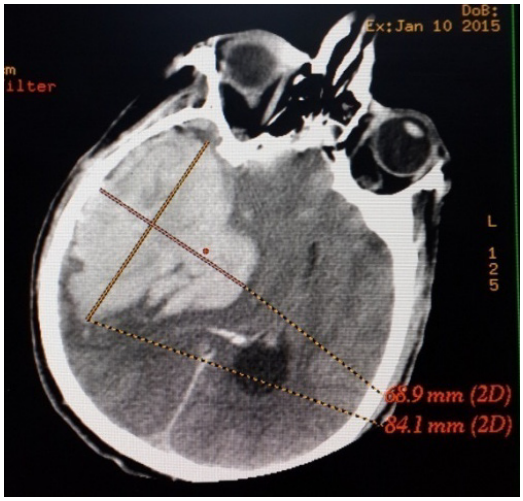
Patients: This study represents a retrospective analysis of 54 patients (61.11% male and 38.89% female) with clinical signs of ICH who underwent brain CT scan. Clinical and laboratory parameters were obtained by reviewing the medical histories of the patients. The average age of examined patients was 67.20±10.30 years (range 43-86). Patients with incorrect examination due to technical reasons, which included non-cooperation of the patient or insufficient concentration of the contrast agent in the arteries were excluded from this study.

Methods: Head CT examination was performed on the CT with 16 rows of detectors (GE CT/e Dual, GE Lightspeed 16; GE Medical Systems, USA). Slice thickness was 0.625 mm. MSCT angiography was performed by standard protocol with manual start and slice thickness of 0.625 mm. Native standard CT protocol for brain examination includes scanning field from C2 vertebral body to vertex, while MSCT angiography field includes scanning of the aortic arch to the vertex. The patient is in the supine position with a cannula placed 18-20 G in the cubital artery. Non-ionic contrast medium Ultravist 370 (iopamid, Bayer Schering Pharma, Germany) is applied in the amount of 50-80 ml with a flow rate of 4-5 ml/sec with a double-headed automatic injector. Scanning parameters include the 120 kv and 300 mA, with a rotating X-ray tube of 0.33 seconds. After the software reconstruction of native and angiography CT scans, the analysis of multi-planar image reconstruction (MPR) was enabled in all three standard projections: coronal, sagittal and axial. MSCT angiography was analyzed in 2D and 3D projections on a workstation Advant-age Work-station 4.1 (AW 4.1).

The following postprocessing techniques were used:

1. 3D volume rendering (VR)
2. maximum intensity projection (MIP)
3. multi-planar reconstruction (MPR)

Volumetric measurement. One method of intracerebral hematoma volume measuring that was used in this study is the method of applying the formula for the elliptic equation - ABC/2 (Figure 1.a).

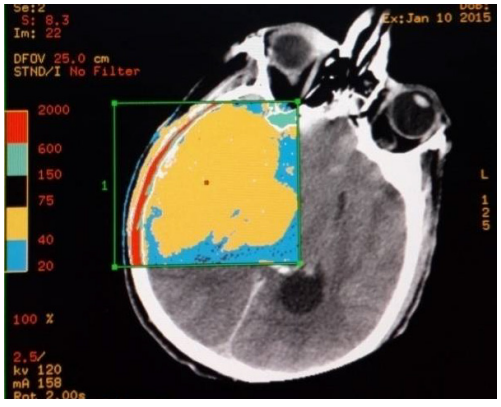


a

Figure 1. Measuring the volume of intracerebral hemorrhage by ABC/2 method (a)

Measurement was conducted in the program within the Advantage Workstation (General Electric Company, Waukesha, USA). Slices with the largest surface area of hematoma were chosen. Parameter A is the largest diameter of the hematoma; parameter B is the largest perpendicular diameter in relation to the parameter A and third parameter C is a diameter perpendicular in relation to the parameters A and B in the multiplanar reconstruction. The values of A, B and C are multiplied and then divided by two.

Another method for intracerebral hematoma volume measuring is a method with computer software, where the volume of ICH is measured by a semiautomatic process (Figure 1.b).



b

Figure 1. Measuring by semiautomatic method by computer analysis (b).

All images were processed with an image processing software on the workstation Advantage Windows 3-D work-station 4.1 (General Electric Company, Waukesha, USA). Firstly, the region of interest (ROI) was chosen by manual marking and selecting, which is then separated from the

environment automatically (software) based on a fixed threshold in Hounsfield's units (HU). The isolated regions were visually inspected and manually adjusted to ensure that the hemorrhage is shown in all three projections. Threshold of hematoma is manually adjusted from 40 to 75 HU. Using a threshold value for distinguishing hematoma and edema of the surrounding brain tissue, adjacent voxels automatically summarize and thereby provide a volume of hematoma.

Statistical analysis. All values were processed in Microsoft Excel (version 2007) and the Statistical Package for Social Sciences (Windows XP, IBM SPSS version 22.0). The results were statistically analyzed using the Student's t-test and Pearson's correlation test; $p<0.05$ was considered as statistically significant.

Results

The most common cause of ICH was elevated blood pressure in 85.19% of all cases (Table 1). In 20 patients in addition to ICH, intraventricular hemorrhage was also recorded (37.04 %).

Table 1. Causes of ICH

ICH causes	Aneurysm	Trauma	High blood pressure
%	12.96	1.85	85.19

CT angiography showed intracranial aneurysms in 12.96% patients. In patients with ICH caused by the arterial hypertension and trauma, CT angiography was normal, without the signs of intracranial aneurysms or arteriovenous malformations.

The values obtained by these two methods are shown in Table 2. The mean value and standard deviation of ICH obtained using ABC/2 method was 41.98±35.47, while the mean value and standard deviation obtained by the method with computer software was 52.12±45.61.

Table 2. Mean values and standard deviation of ICH obtained by ABC/2 method and computer method

	ABC/2 method	AW 4.1 software
mean value	41.98	52.12
SD	35.47	45.61
absolute difference	10.14	
difference (%)	19.46	

There is a statistically significant difference between the values obtained by these two methods ($p=0.03$). Absolute difference was 10.14 cm^3. The values obtained by the computer method were by 19.46% higher than those obtained by ABC/2 method. The linear regression analysis shows a strong positive correlation between ICH volume values measured both with ABC/2 method (y) and computer semiautomatic method (x) ($r=0.852$) (Figure 2).

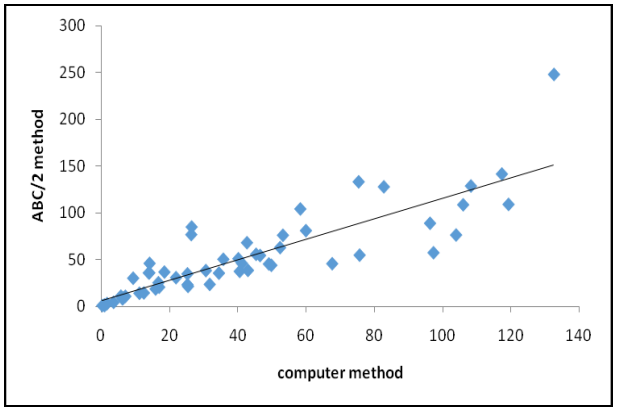


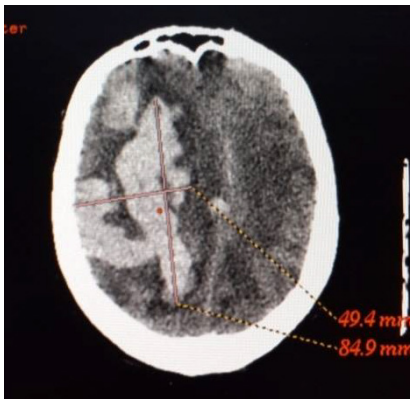
Figure 2. Linear regression analysis shows a strong positive correlation between ICH volume values measured both by ABC/2 method (y) and computer semiautomatic method (x) ($r=0.852$).

There is no statistically significant difference between the values obtained in male and female patients using both methods ($p>0.05$).

Only two hematomas were located in cerebellar hemispheres (3.7%), while all the others were located in the cerebral hemispheres (96.3%).

Discussion

Both methods proved to be very useful for determining the volume of ICH. ABC/2 method is suitable for measuring regular shape of ICH and for a quick orientation, while for the irregular shape it cannot be considered reliable (Figure 3). In that case, it is more precise to use a computer analysis method. In our study, the values obtained by the formula were by 19.46% lower compared with the values obtained by computer processing. This may be due to non-disjunction of regular and irregular shapes of hematoma. In the study by Maeda et al. (8), the values determined by ABC/2 method in relation to the planimetric method were by 14.9% lower (2.24 cm^3), while Wang et al. showed in their study (9) that values obtained by ABC/2 method significantly exceed the values obtained by computer analysis, which can pose a problem in clinical decision making, mortality forecasting and functional results. In various studies different values of absolute difference (1-4 cm^3) between the compared methods (using formulas and planimetric method) were obtained, and thereby it is considered that the validity of the ABC/2 formula is lower in large hematomas (2,10,11). This may justify the values obtained in our work, because the average value of hematoma in our study (41.98 cm^3) was far higher than those reported in the literature, and therefore the absolute difference between the above methods (10.14 cm^3).



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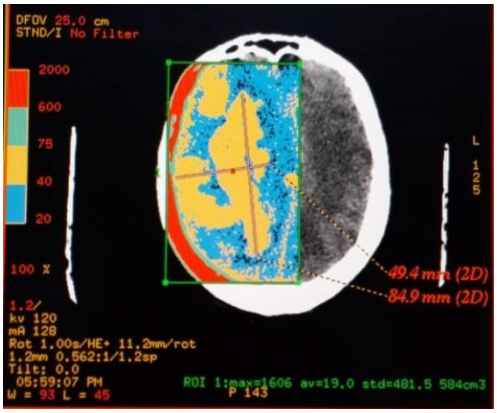

b

Figure 3. Measuring the volume of intracerebral hemorrhage with an irregular shape by ABC/2 method (a) and measuring by semiautomatic method with computer analysis (b).

Measuring the volume of hematoma by ABC/2 method is useful until hemorrhage is not multilobular (Figure 4) or has a very irregular shape (12). In the reference literature we found that there were methods compared with elliptic formula ABC/2 and computer analysis method (CAVA – computer-assisted volume analysis) with the help of various software programs on the basis of volumetric DICOM images, but in the literature we did not find the software for volumetric measurement with the determination of the threshold in HU units as in our research. We consider that this method is quite accurate in relation to the other, because the hematoma can be clearly distinguished from the surrounding brain tissue and surrounding edema, due to the high contrast between these objects. The disadvantage of this method is the inability of demarcation of ICH from intraventricular hemorrhage, and in this case it is necessary to manually mark a hematoma.

Conclusion

Both methods are useful for determining the volume of ICH. Our results showed that the values obtained by the elliptic equation - ABC/2 were by 19.46% lower compared with the values obtained by semiautomatic method with computer volumetric analysis. Elliptic equation - ABC/2 method is suitable for measuring regular-shaped ICH and for fast orientation, whereas we believe that the semiautomatic method with computer volumetric analysis is more precise and selective.

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KOMPARACIJA METODE ELIPTIČKE JEDNAČINE – ABC/2 I POLUAUTOMATIZOVANE METODE UZ POMOĆ KOMPJUTERA ZA MERENJE VOLUMENA INTRACEREBRALNE HEMORAGIJE

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Zapremina hemoragije, nivo svesti i postojanje intraventrikularnog širenja predstavljaju prognostičke činioce za klinički ishod intracerebralne hemoragije (ICH). Volumetrijsko merenje ICH ima veliki klinički i prognostički značaj.

Cilj rada bio je poređenje metoda koje se koriste za izračunavanje volumena ICH: putem formule za eliptičnu jednačinu (ABC/2) sa izračunavanjem pomoću semiautomatizovane metode kompjuterskim volumetrijskim programom.

Istraživanje predstavlja retrospektivnu analizu 54 bolesnika (61,11% muškaraca i 38,89% žena, prosečne starosti 67,20±10,30 godina) koji su bili podvrgnuti kompjuterskoj tomografiji (CT) endokranijuma. Volumetrijska merenja izvršena su pomoću metode za eliptičnu jednačinu ABC/2 i pomoću kompjuterskog programa na radnoj stanici Advantage Windows 3D Workstation 4.1.

Srednja vrednost i standardna devijacija ICH dobijene metodom ABC/2 iznosi 41,98±35,47, dok za metodu sa kompjuterskim softverom iznosi 52,12±45,61. Postoji statistički značajna razlika između vrednosti koje su dobijene korišćenjem obe metode ($p=0,03$). Apsolutna razlika iznosi 10,14 cm^3. Vrednosti koje su dobijene kompjuterskom metodom su za 19,46% više u odnosu na one dobijene pomoću formule. Postoji statistički jaka pozitivna korelacija između ove dve metode ($r=0,852$, $p<0,05$).

Obe metode su korisne za određivanje volumena ICH. Naši rezultati pokazuju da su vrednosti volumena ICH dobijene metodom jednačine za 19,46% niže u odnosu na vrednosti dobijene metodom uz pomoć komjuterskog volumetrijskog programa. Metoda eliptične jednačine je pogodna za merenje ICH pravilnog oblika i za brzu orjentaciju, dok je metoda uz pomoć kompjuterskog programa preciznija i selektivnija. *Acta Medica Medianae 2015;54(3):34-38.*

Ključne reči: *intracerebralna hemoragija,* kompjuterska tomografija (CT)*, volumetrijsko merenje*