RESEARCH STUDIES

Ultrasound integrated neuronavigation – a standard tool for planning and guidance in the neurosurgery

Gr. Zapuhlih[1], M. Ivanov[2,3], V. Galearschi[1], *A. Peciul[1], C. Dogaru[1]

[1]Department of Neurosurgery, Institute of Neurology and Neurosurgery, Chisinau, the Republic of Moldova
[2]Royal Hallamshire Hospital, [3]Sheffield Teaching Hospital, Sheffield, United Kingdom
*Corresponding author: andrei.peciul@gmail.com. Manuscript received January 22, 2014; accepted April 05, 2014

Abstract

Background: Intraoperative ultrasound provides a low cost real time imaging that is quick and simple to use. In recent years there has been a significant improvement in the quality of ultrasound imaging. Ultrasound integrated neuronavigation can be used to optimize the lesion approach and achieve a safe maximal resection, thereby improving the outcomes of the patients with different localizations and histologic types of brain tumors, vascular pathology, spontaneous intracerebral hemorrhage.

Material and methods: From 2007 to 2010 in the Institute of Neurology and Neurosurgery 130 operations with the application of 2D intraoperative ultrasound (US) were performed. From March to May 2012 17 patients underwent a surgical treatment with the usage the intraoperative ultrasound integrated neuronavigation system.

Results: We have applied ultrasound neuronavigation system in 17 cases on the patients with diverse pathologies, including brain tumors (craniopharyngeoma, corpus collosum and intracerebral glioblastoma, intraaxial glioma), vascular pathology (arteriovenous malformations, aneurysms), spontaneous intracerebral hemorrhage. The application of ultrasound neuronavigation system helps in improving the postoperative outcomes of these patients.

Conclusions: The integration of 3D US with neuronavigation technology has created an efficient and inexpensive tool for intraoperative imaging in neurosurgery. The technology has been applied to optimize the surgery of brain tumors, but it has also been found useful in other procedures, such as operations for aneurysms or arteriovenous malformations. Intraoperative ultrasound is easy to use and has a rapid assessment curve which makes it a useful tool of the neurosurgeons' intraoperative armamentarium.

Key words: intraoperative ultrasound, intraoperative monitoring, neuronavigation, neurosurgery.

Introduction

A reliable intraoperative orientation is essential in neurosurgery. Anatomical topographic landmarks, frame based and frameless neuronavigation and intraoperative ultrasound (iUS) allow the neurosurgeon to localize the lesion and surrounding structures, to optimize the lesion approach and to achieve a safe maximal resection [1, 2]. In the brain tumor surgery a real time imaging has its advantages over preoperatively derived images as during the excision the brain structures move and cerebrospinal fluid (CSF) is lost, and the above leads to the brain shift, which makes the navigation based on preoperative images inaccurate [3, 4]. Also during the surgery some new features can develop (hydrocephalus, haemorrhage, etc) [2]. Intraoperative ultrasound is comparatively inexpensive, easy to use and requires little intraoperative equipment or upkeep.

Intraoperative sonography has been used in neurosurgery since the 50s (intially as A-mode US). In 1960 B-mode ultrasound became available. In the late 80s a computer technology had developed to a stage that made possible the usage of preoperative image data for specifying the position of a tool in the brain, thereby the concept of neuronavigation was born [1]. The recent advances in probe technology, image fusion, 3D techniques have provided considerable improvements of the image quality [2].

Goals:

- Optimizing the lesion approach and achieving a safe maximal resection using confident intraoperative orientation.
- Improving the outcomes by applying integrated ultrasound neuronavigation for the patients with different localizations and histologic types of brain tumors, vascular pathology, spontaneous intracerebral hemorrhage [2, 5].

Material and methods

From 2007 to 2010 in the Institute of Neurology and Neurosurgery 130 operations with application of 2D iUS were performed [5]. From March to May, 2012, 17 patients underwent a surgical treatment using the intraoperative ultrasound integrated neuronavigation system (fig. 1, 2, 3, 4).

Fig. 1. The patient should be positioned properly in order a vertical access to the lesion can be obtained to fill the operation cavity with water [6].

Principles of 2D and 3D iUS image acquision

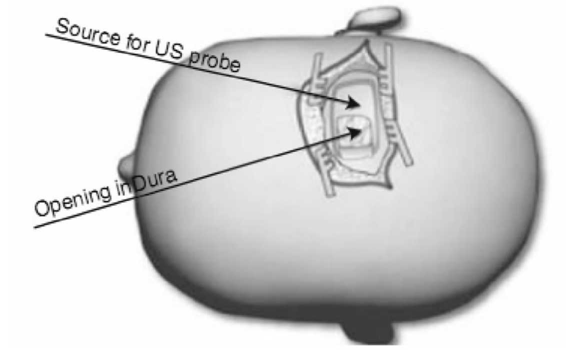

Fig. 2. Images are taken at an angle and aside from the operation access, therefore, reducing the artifacts [6].

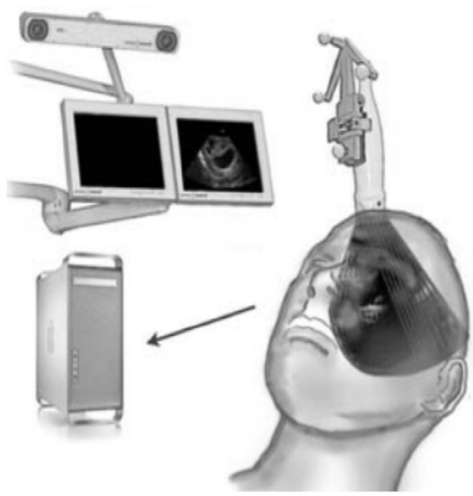

Fig. 3. 3D US image acquisition is done during the operation every time it is needed. The probe is moved over the region of interest, while each of the 100–200 images with the position data is tagged from the optical tracking camera and reconstructed into a regular 3D volume. It takes about 30 seconds to create a new 3D US volume [1].

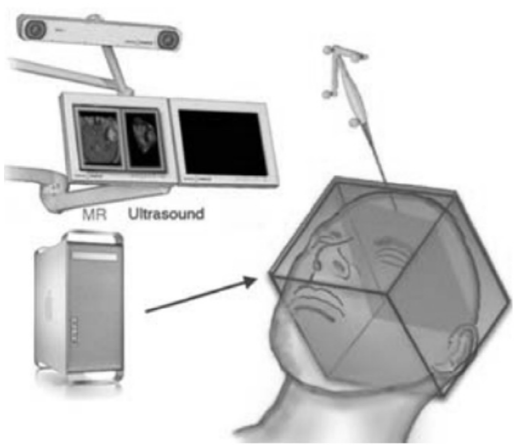

Fig. 4. The pointer steers the display of 3D volume [1].

Accuracy of 3D ultrasound

In case of standard neuronavigation system the overall clinical inaccuracy consists of the following: registration inaccuracy (often more than 5 mm), technical inaccuracy (navigation system itself) and the inaccuracy due to the brain shift. For US integrated neuronavigation the registration inaccuracy is eliminated because both US acquisition and navigation based on 3D images is done in the same reference system. The inaccuracy due to the brain shift can be fixed by the repeated acquisitions of 3D US during the operation.

Once the craniotomy has been performed, iUS can be used to localize the lesion and such neuroanatomical structures as ventricle, falx, choroid plexus, main vessels, and to assess the brain shift (responsible factors – gravity, brain swelling, CSF loss, tumor debulking).

Intraoperative US can be used during the surgical procedure to check if the tumor removal is completely performed before the total excision is finished (the majority of all metastases, meningiomas, cavernomas, abscesses, craniopharyngiomas and some gliomas).

Applications for 3D ultrasound based neuronavigation

– Surgery of brain tumors;
– Planning of the surgery;
– Biopsies;
– Operation guiding;
– Resection control;
– Skull base surgery;
– Endoscopy– Cavernous haemangiomas;
– Intracerebral haematomas;
– Aneurysms;
– Arteriovenous malformations (AVMs) surgery.
– Intra-spinal pathology

Our experience (fig. 5, 6, 7, 8, 9, 10). 3D ultrasound based neuronavigation has been applied in:

- Neurooncology (tumor localization, resection control)
  - Corpus callosum and intracerebral glioblastoma
  - Intraventricular craniopharyngeoma
  - Occipital astrocytoma
  - Recurrent vestibular schwannoma
- Localization and identification of vascular lesions
  - AVM Spetzler-Martin grade IV
  - Artery aneurysm
  - Spontaneous intracerebral hemorrhages.

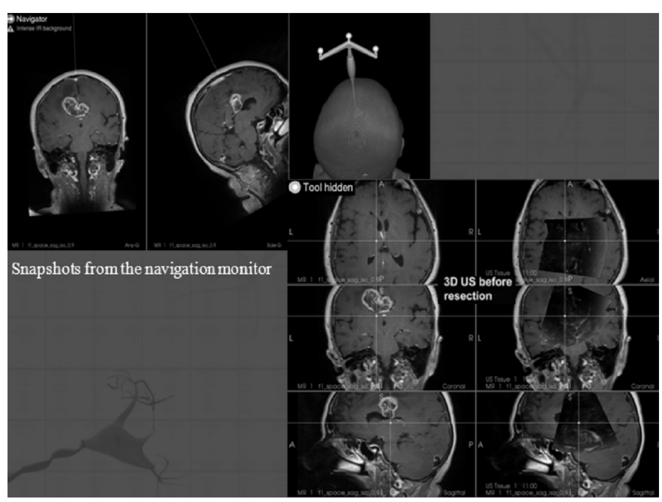

Fig. 5. Intraoperative 3D US image acquisition of the patient F (female, 39 years old) with corpus callosum glioblastoma.

Curierul medical, April 2014, Vol. 57, No 2

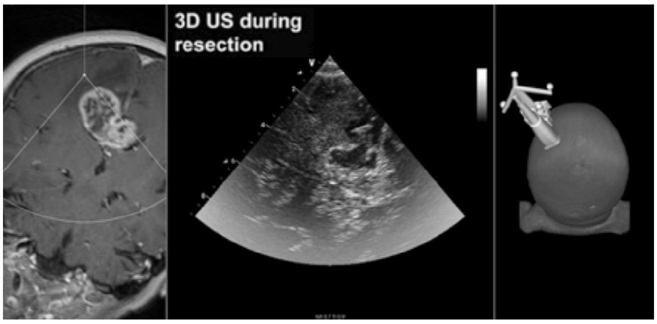

Fig. 6. The same patient. Resection guidance using intraoperative 2D US.

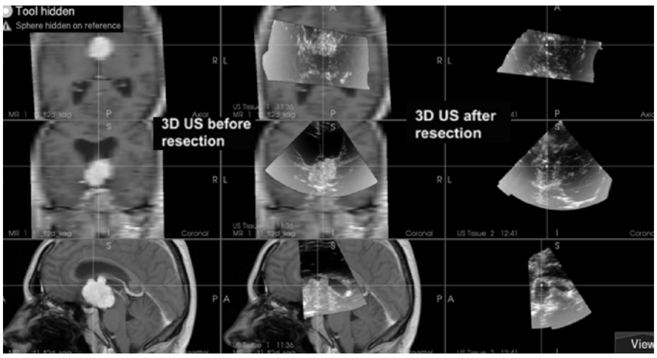

Fig. 7. Patient M (male, 29 year old) with intraventricular craniopharyngeoma.

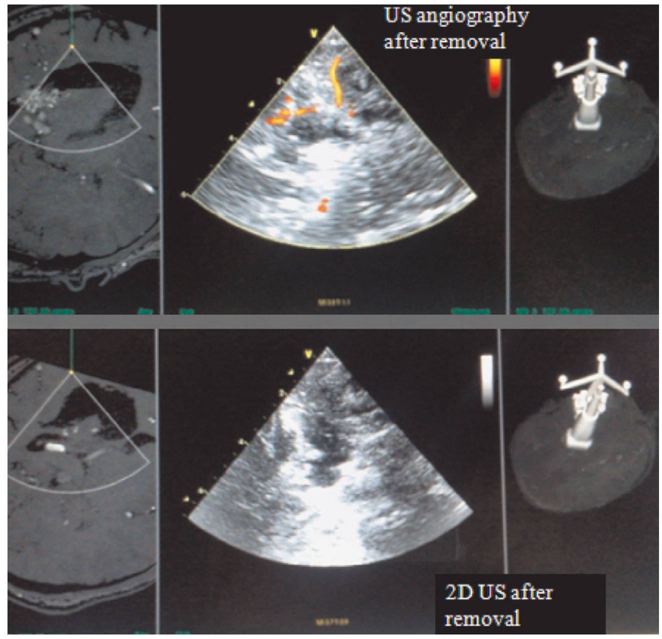

Fig. 9. The same patient. Image acquisition (2US angiography – up and conventional 2D US – down) after AVM removal.

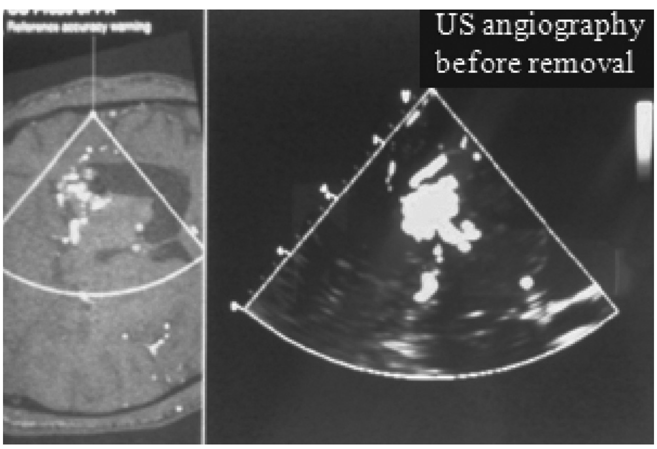

Fig. 8. Patient M, 28YO with left temporal AVM, Spetzler-Martin's grade IV. We have used US angiography based on the recordings of Doppler's signals power from the blood stream.

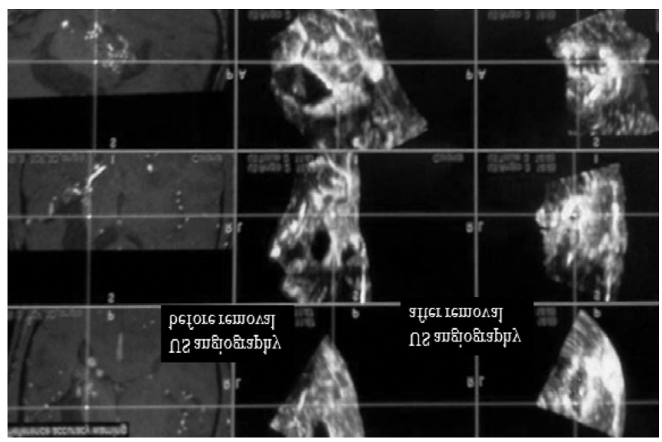

Fig. 10. The same patient. Image acquisition (3D US angiography) before and after AVM removal.

Conclusions

Ultrasound integrated neuronavigation is useful in intraoperative imaging of most brain tumors, besides it enables to work safer, faster and always with more confidence in removing intraaxial tumors, especially, in clearly cut-off areas and without producing any permanent neurological deficit. Also iUS can be utilzed in the resection guidance and gaining the possibility to perform a total tumor removal. Using intraoperative color Doppler (US angiography) provides the information about vascular structures, aneurysms and deep-seated AVMs localizations, a blood flow and a vasospasm, allows the real time evidence of vessel patency or flow disruption, following anevrysm clipping or AVM removal. It has also been found useful in identifying feeders and draining vessels and for resection control of AVMs [7]. Our experience showed that ultrasound integrated neuronavigation is efficient in optimizing the surgical procedure and the patient outcome. iUS is a low cost intraoperative imaging modality, which with current technological improvements can be as informative as low-field intraoperative MRI. Intaroperative US is easy to use and has a rapid learning curve which makes it a useful tool of the neurosurgeons' intraoperative armamentarium.

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Hygienic assessment of effectiveness of *Echinacea purpurea* tinctures in case of combined exposure of imidacloprid and sodium nitrate

***O. Korotun, L. Vlasyk**

Department of Hygiene and Ecology, Bukovinian State Medical University, Chernivtsi, Ukraine

*Corresponding author: elena_korotun@mail.ru.

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Abstract

Background: In conditions of modern denaturated environment, one of the most important tasks of medical science is to find out the possibilities that could enlarge the adaptive-compensatory abilities of the organism. In accordance with the recent scientific data, the stability of biosystems against the action of external factors might be enhanced 1.5-2 times, only with the help of biological methods of prophylactic. The aim was to provide a hygienic evaluation of protective properties of *Echinacea purpurea* tincture in case of oral exposure of imidacloprid and sodium nitrate considering acetylation phenotype.

Material and methods: The experiment was conducted on 36 white male rats. Intoxication was modeled by intragastric administration of imidacloprid and sodium nitrate in the threshold doses for 28 days. Tincture of *Echinacea purpurea* was injected 1.5 hours before the introduction of toxins in a dose of 0.25 ml/kg.

Results: Pretreatment with a tincture of Echinacea leads to an improvement of some indicators of health in case of combined intoxication of imidacloprid and sodium nitrate. Changes of integral indicators (body weight, behavioral reactions) occured later, moreover, less pronounced hypoxic syndrome, tended to normalize liver detoxication and improvement of antioxidant system were observed in the animals with the “fast” type of acetylation. The signs of improvement in antioxidant defense were found in “slow” acetylators. At the same time, growth of total protein level of blood plasma in “fast” and the increase in plasma cholesterol, as well as an upward trend in alanine transferase in “slow” acetylators were detected.

Conclusions: Prescription of *Echinacea purpurea* for the purpose of prevention of harmful effects of imidacloprid and sodium nitrate should be performed selectively according to the type of acetylation and functional state of the liver.

Key words: *Echinacea purpurea*, imidacloprid, sodium nitrate, acetylation phenotype.

Гигиеническая оценка эффективности использования настойки эхинацеи пурпурной при комбинированной интоксикации имидаклопридом и нитратом натрия

Введение

В условиях современной денатурированной окружающей среды важным заданием медицинской науки является расширение адаптационно-компенсаторных возможностей организма, определение их границ до преморбидного состояния. По данным научных исследований стойкость биосистем к внешним воздействиям можно увеличить в 1,5-2 раза, в частности, при помощи средств биологической профилактики [1]. Поэтому одним из приоритетных направлений современной гигиены является поиск средств профилактики вредного воздействия ксенобиотиков. При решении вызовов в области гигиены окружающей среды ВОЗ рекомендует использование во всех возможных случаях профилактических подходов, при особенном внимании к высоковосприимчивым группам населения. [2, 3]. Важное место среди них занимают средства биологической профилактики при помощи натуральных веществ, обладающих общеукрепляющим, антиоксидантным, адаптогенным воздействием [4]. Ранее нами было показано, что «быстрый» тип ацетилирования является биомаркером восприимчивости к токсическому влиянию таких распространенных и опасных загрязнителей как имидаклоприд (инсектицид группы неоникотиноидов) и нитрат натрия [5]. Из данных литературы известно, что настойка эхинацеи пурпурной проявляет протекторные свойства при нитратно-кадмиевой [6], кадмиевой [7], а также свинцово-нитратной [8] интоксикациях. Однако, отсутствуют данные о протекторном влиянии этого препарата при комбинированных нитратно-пестицидных интоксикациях.