

THE USE OF POSITRON EMISSION TOMOGRAPHY
AND COMPUTED TOMOGRAPHY WITH 18F-FLUORODEOXYGLUCOSE
AS A SELECTION CRITERION FOR SURGICAL TREATMENT
IN CHILDREN WITH DRUG-RESISTANT EPILEPSY (literature review)

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<https://doi.org/10.35339/ic.2025.12.3.roh>

ABSTRACT

Background. In the contemporary context, the management of paediatric patients afflicted with drug-resistant epilepsy continues to represent a significant challenge for specialists in the field of paediatric neurology. This persistent predicament underscores the imperative for the development of precise and non-biased criteria to facilitate the selection of candidates for surgical intervention. The integration of Positron Emission Tomography with Computed Tomography with 18F-FluoroDeoxyGlucose (18F-FDG PET/CT) and high-resolution neuroimaging has the potential to facilitate a personalised approach and to identify candidates for surgical treatment.

Aim. To ascertain the diagnostic and prognostic role of positron emission tomography with 18F-fluorodeoxyglucose in combination with computed tomography in the selection of paediatric patients with drug-resistant epilepsy for surgical treatment.

Materials and Methods. The work employed a range of methodological approaches, encompassing theoretical generalisation, analysis and synthesis of results. The search for relevant works was conducted in the scientometric Scopus, Web of Science, PubMed, Google Scholar databases. The research was conducted as a private initiative of the authors, did not receive funding from grant programs, and the research topic was not officially registered in the state register.

Research Ethics. During work, studies were selected whose authors demonstrated adherence to ethical standards.

Results. The sensitivity of 18F-FDG PET/CT in localising the epileptogenic focus was found to range from 80.0% to 89.0%, with the specificity of 78.0%. The combination of PET with magnetic resonance imaging has been shown to enhance the accuracy of identifying the affected area to 85.0%. Quantitative assessment of hypometabolism using automated analysis programs (CortexID, Morphometric Analysis) has significant prognostic value for predicting postoperative outcomes. The utilisation of digital systems and algorithms of quantitative analysis serves to enhance the reliability of the results, while the absence of uniform standards continues to represent a significant limitation.

Conclusions. 18F-FDG PET/CT is a highly effective method of preoperative diagnosis, which improves the quality of selection of children for surgical treatment of drug-resistant epilepsy. Integration of PET/CT with other neuroimaging technologies, quantitative assessment of metabolism and further standardisation of protocols are promising avenues for the development of personalised diagnostics in paediatric neurology.

Keywords: *medical radiology, paediatric, treatment effectiveness, epileptogenic focus, metabolic activity.*

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Introduction

Nowadays, Drug-Resistant Epilepsy (DREP) in children remains one of the most difficult problems in paediatric neurology, which necessitates the search for new approaches to accurate diagnosis and personalised treatment. Despite the achievements of drug therapy, about a third of paediatric patients do not achieve seizure control even with the combined use of antiepileptic drugs [1; 2].

In such cases, the main method of achieving stable remission is surgical intervention, the effectiveness of which directly depends on the accuracy of identifying the epileptogenic focus.

Surgical interventions in children diagnosed with DREP are planned based on various diagnostic measures, including electrophysiological testing and neuroimaging. The results of epilepsy surgery are promising, with high chances of recovery, particularly in cases of a temporal lobe epilepsy, which leads to a significantly higher absence of seizures after surgery compared to drug treatment. However, localisation of the zone of onset of seizures in DREP, and the identification of epileptogenic zones, including the determination of their boundaries, remains a challenging task [3; 4].

Whilst classical neuroimaging methods, including Magnetic Resonance Imaging (MRI), ElectroEncephaloGraphy (EEG) and video-EEG monitoring, remain fundamental tools for preoperative assessment, they do not always permit the identification of structural and functional changes in the cortex [5–7]. In this regard, the role of Positron Emission Tomography with 18F-FluoroDeoxyGlucose in combination with Computed Tomography (18F-FDG PET/CT) is increasing as a highly sensitive method capable of displaying areas of hypometabolism [3; 8; 9].

Recent years have been characterised by a significant increase in the diagnostic accuracy of PET/CT due to its integration with high-resolution neuroimaging and the introduction of quantitative data processing algorithms, in particular the CortexID and Morphometric Analysis Programme [7; 10]. This allows not only to identify lateralized hypometabolic areas of the cortex, but also to perform a semi-quantitative assessment of metabolic activity, considering individual variations in brain asymmetry [11; 12].

In most countries worldwide, the proportion of children who have access to surgical treatment of epilepsy does not exceed 1% of potential candidates. This finding suggests an underestimation of the role of preoperative neuroimaging [2]. Concurrently, the timely and accurate localisation of the epileptogenic focus enhances the efficacy of surgical intervention, mitigates the risks of cognitive disorders, reduces the duration of drug therapy and improves the quality of life of the child [11; 13; 14].

Consequently, the generalisation of modern scientific data on the use of 18F-FDG PET/CT in the preoperative diagnosis of DREP in children is an urgent and necessary task. A thorough analysis

of international experience enables an evaluation of the prognostic and diagnostic capabilities of the method, and the identification of factors that affect its accuracy.

Aim and objectives

The **aim** of the study was to ascertain the diagnostic and prognostic role of positron emission tomography with 18F-fluorodeoxyglucose in combination with computed tomography in the selection of paediatric patients with drug-resistant epilepsy for surgical treatment.

The **objectives** of the study were:

1) to analyse modern literature sources on the use of 18F-FDG PET/CT in preoperative diagnosis of FRE in children, identifying the main directions of development of this technology in clinical neurology;

2) to assess the diagnostic effectiveness of 18F-FDG PET/CT in determining the localisation of the epileptogenic focus compared to other neuroimaging methods (MRI, EEG, video-EEG monitoring), considering age-related features of brain metabolism;

3) to systematise the prognostic indicators of 18F-FDG PET/CT that correlate with successful results of surgical treatment, and to outline the factors that affect the accuracy and clinical informativeness of the method.

Materials and Methods

The work used methods of theoretical generalisation, analysis and synthesis of results. The search for relevant works was conducted in the scientometric databases Scopus, Web of Science, PubMed and Google Scholar.

Research Ethics

During the work, studies were selected whose authors adhered to ethical standards.

Results

Modern epidemiological studies indicate that the frequency of DREP in children is from 20.0 to 30.0% among all cases of epilepsy, and about half of such patients have structural lesions of the cerebral cortex, which can be detected by neuroimaging [1; 2]. Early diagnosis of this pathology is of great importance, since the long-term persistence of uncontrolled seizures leads to impaired cognitive development, behavioural disorders and social maladjustment of the child. According to Beatty C.W. et al. (2021) [2], surgical treatment of paediatric epilepsy remains underutilised, despite its proven efficacy and low complication rates.

Despite the existence of a plethora of antiepileptic medications, remission remains elusive for a considerable number of paediatric patients. This

underscores the importance of surgical intervention as a viable and effective treatment option for individuals suffering from seizures. The efficacy of surgical intervention is contingent upon the precision of identifying the epileptogenic focus and the judicious selection of candidates. The purpose of complex neuroimaging with 18F-FDG PET/CT is to provide further insight into the underlying pathophysiology of the condition [13–15].

According to contemporary scientific research, the use of 18F-FDG PET/CT for diagnostic purposes offers a high degree of sensitivity in detecting metabolically inactive areas of the cortex, corresponding to epileptogenic foci. In the study by Steinbrenner M. et al. (2022) [8], the diagnostic accuracy of PET/CT was established at 85.0%, and the specificity was 78.0% in histologically confirmed forms of temporal lobe epilepsy. Furthermore, it was demonstrated that in 60.0% of patients with foci not determined by MRI, PET/CT revealed additional areas of hypometabolism, which were consistent with EEG results. Quantitative analysis of SUVmax has proven prognostic value. In the study by Steinbrenner M. et al. (2022) [8], the median SUVmax in the epileptogenic focus zone was 4.8 (IQR 3.9–5.7), which was significantly lower than in the contralateral symmetrical area ($p < 0.001$). Li S. et al. (2024) [10] demonstrated that a 15% asymmetry threshold in SUVmax-based metabolism provided 82.0% sensitivity and 76.0% specificity for pre-operative localization of the epileptogenic focus. Sainburg L.E. et al. (2025) [11] showed that a lateralized hypometabolism zone with a $\geq 20\%$ reduction in SUVmax relative to the contralateral area was associated with a seizure-free period of two years after surgery in 84.0% of children. In addition, the high efficiency of the method was confirmed in the meta-analysis by Courtney M. et al. (2024) [4]. The presence of a clearly localised hypometabolic zone correlated with a successful surgical outcome in 72.0% of cases, while in diffuse or multifocal hypometabolism the success of the intervention decreased to 48.0%.

It has been established that in cases of MRI-negative forms, PET/CT may be the sole method that allows detecting hypometabolic areas of the cortex corresponding to foci of pathological activity [3; 6; 7]. Concurrently, it is imperative to consider age-related variations in glucose metabolism in children. The activity of glucose metabolism in the child's brain is significantly different from that of the adult. This requires the use of separate age-

specific reference values for the interpretation of PET images [16].

Scientific observations of recent years confirm that integrated PET/CT and PET/MRI methods demonstrate more accurate localisation of epileptogenic foci compared to separate structural methods, especially in cases of implicit morphological changes [3; 5; 17]. Similar results were obtained in the meta-analysis of Courtney M. et al. (2024) [4], which confirmed the association between localised hypometabolism and successful seizure control after resection in 72% of cases.

Despite the high informativeness, the results of PET/CT depend primarily on the conditions of the study, including the period between attacks, the depth of sedation and correction of the child's blood glucose level. The study by Carvalho et al. (2022) [18] indicated that deviations in time from the last attack of more than 48 hours can reduce the accuracy of image interpretation by 10–15%. In addition, the type of data reconstruction and software can affect the results. The implementation of artificial intelligence and machine learning algorithms for automatic segmentation of hypometabolic areas has been actively developing in recent years [9; 19].

The use of automated analysis programmes (Morphometric Analysis Program, CortexID) facilitates the transition from subjective image assessment to quantitative characterisation of hypometabolic regions. In the study by Li S. et al. (2024) [10], it was demonstrated that the CortexID technique has sensitivity of 82.0% in detecting epileptogenic zones in temporal lobe epilepsy. Furthermore, it was found to allow for quantitatively assessment of the level of metabolic reduction in percentage relative to control areas. The utilisation of digital PET/CT systems has been demonstrated to yield favourable outcomes, characterised by enhanced image contrast, diminished scanning duration, and reduced noise [20].

The findings of contemporary studies show that indicators of hypometabolism on PET/CT can function as autonomous prognostic markers of the success of surgical intervention. In the work of Sainburg L.E. et al. (2025) [11] it has been established that lateralized zones of hypometabolism are associated with a long seizure-free period in 84.0% of children within two years after surgery. Similar data are given in the study of Wang F. et al. (2024) [12], where in patients with focal cortical dysplasia type II the positive predictive accuracy of PET/CT was 80.0%, and the lack of a clear

localisation of hypometabolism increased the risk of seizure recurrence by 2.1 times. This facilitates not only the precise determination of the lesion's localisation, but also the prediction of the outcome of surgical intervention.

Discussion

The generalisations obtained from the literature data are compelling and indicate that 18F-FDG PET/CT occupies a central place in the pre-surgical diagnosis of FRE in children. This method has been demonstrated to provide a high level of detection of epileptogenic zones even in the absence of structural changes on MRI. As shown by Steinbrenner M. et al. (2022) [8], Guo K. et al. (2025) [3], the sensitivity of the method exceeds 80.0%, while the specificity was 78.0%. This efficiency can be attributed to the capacity of PET/CT to reflect metabolic changes in neurons, rather than morphological changes, thereby ensuring the early detection of epileptogenic areas before the onset of macroscopic changes.

It is important to note that in childhood, when MRI-negative forms are established, PET/CT often becomes a key technique in determining surgical tactics. It was found that localised hypometabolism as evidenced by PET scanning was an independent predictor of successful surgical outcome [4]. Moreover, a decline in metabolism lateralisation has been observed to be concomitant with protracted seizure-free periods in 84.0% of children [11]. This confirms that hypometabolism is not only a marker of focal activity, but also an indicator of prognosis after surgery.

It has been found that the integration of PET data with MRI significantly increases diagnostic accuracy [3]. This indicates the feasibility of using multiparametric approaches, especially in paediatric practice, where anatomical variability and physiological changes in metabolism complicate the interpretation of results. Concurrently, disparities in PET/CT techniques, 18F-FDG dosage, and image reconstruction parameters engender variability in results between centres [9; 16; 19; 21]. This indicates the need for further standardisation of protocols. As Tian M. et al. (2021) [16] observe, the implementation of unified age-specific metabolic norms will reduce discrepancies in 20–25% of cases. In the context of predicting postoperative outcomes, most authors concur that accurate localisation of the hypometabolic area on PET/CT significantly increases the likelihood of successful resection and reduces the risk of relapse [11; 22; 23]. It was found that patients with clear metabolic lateralisation had a lower probability of

recurrence compared to those with diffuse PET changes [12].

Consequently, the analysis indicates that 18F-FDG PET/CT is an indispensable component of a contemporary multidisciplinary approach to the management of children with FRE. The method has been demonstrated to serve a dual purpose; firstly, it clarifies the lesion site, and secondly, it functions as a tool for predicting the results of surgical intervention. This corresponds to modern concepts of personalised medicine.

Conclusions

18F-FDG PET/CT is a highly sensitive and specific method for presurgical diagnosis of drug-resistant epilepsy in children, which provides detection of epileptogenic zones even in the absence of structural changes on MRI. Integration of PET/CT with MRI or other neuroimaging methods increases the accuracy of localisation of the pathological focus and allows optimising surgical tactics. Quantitative assessment of hypometabolism using and automated analysis programmes (CortexID, Morphometric Analysis) has significant prognostic value for predicting postoperative outcomes.

The 18F-FDG PET/CT technique requires further standardisation of protocols for the paediatric population, considering age-related characteristics of glucose metabolism. The use of PET/CT as part of a multidisciplinary approach contributes to the timely selection of children for surgical treatment, reduces the risk of relapse of seizures, and improves cognitive prognosis.

Funding and Acknowledgments

The research was conducted as a private initiative of the author, did not receive funding from grant programs, and the research topic was not officially registered in the state register of scientific topics.

Declarations

Conflict of interest is absent. The author has consented to the publication of the article under the terms of the Creative Commons BY-NC-SA 4.0 International License and the public agreement with the editorial board, as well as to the processing and publication of his personal data.

The author of the manuscript states that in the process of conducting research, preparing, and editing this manuscript, no generative AI tools or services were used to perform any of the tasks listed in the Generative AI Delegation Taxonomy (GAIDeT, 2025). All stages of work (from the development of the research concept to the final editing) were carried out without the involvement of generative artificial intelligence, exclusively by the authors.

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Received: 08 May 2025

Accepted: 29 Sep 2025

Published: 30 Sep 2025

Cite in Vancouver style as: Romanenko H. The use of positron emission tomography and computed tomography with 18F-fluorodeoxyglucose as a selection criterion for surgical treatment in children with drug-resistant epilepsy (literature review). *Inter Collegas*. 2025;12(3):77-82.
<https://doi.org/10.35339/ic.2025.12.3.roh>

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