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ORIGINAL ARTICLE **ÖZGÜN ARAŞTIRMA**

THE RELATIONSHIP BETWEEN ANGIOGRAPHIC PARAMETERS AND RADIATION DOSE IN PATIENTS UNDERGOING MECHANICAL THROMBECTOMY

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ABSTRACT

INTRODUCTION: Radiation exposure during mechanical thrombectomy (MT) procedure in acute ischemic stroke patients with large vessel occlusion poses risks for both the patient and the neurointerventionalists. In this study, we evaluated the relationship between radiation dose and angiographic parameters in patients undergoing MT.
METHODS: 101 patients who underwent mechanical thrombectomy between January 2022 and December 2022 were prospectively enrolled and retrospectively evaluated. Demographic data, degree of vessel recanalization, good (mRS 0-2) or poor (mRS 3-6) clinical outcome, angiographic procedure times, and radiation dose exposure during the procedure were recorded.
RESULTS: The mean age was 69.9±13.4 years and the National Institutes of Health Stroke Scale (NIHSS) score at presentation was 15.2±5.1. The average time interval from groin puncture to occluded vessel recanalization was 25.1±15.2 minutes, the mean number of passes was 2.1±1.6, and the mean radiation dose was 878.6±555.6 milligrays. There was a significant, mild positive correlation between the number of passes and the radiation dose to which the patient was exposed (r: 0.196, $p<0.05$). There was a significant, moderate positive correlation between time to recanalization of the occluded vessel from groin puncture and the radiation dose to which the patient was exposed (r: 0.416, $p<0.001$).
DISCUSSION AND CONCLUSION: Radiation dose exposure during stroke neurointervention is very important for both neurointerventionalists and patients. Optimum angiographic doses should be determined to obtain suffiecient image quality. First-pass effect and complete recanalization (mTICI3) should be targeted for not only to attain good clinical outcome (mRS 0-2) but also reduce patient exposure to radiation.
Keywords: Mechanical thrombectomy, radiation, acute stroke.

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MEKANİK TROMBEKTOMİ UYGULANAN HASTALARDA ANJİOGRAFİK PARAMETRELER İLE RADYASYON DOZU ARASINDAKİ İLİŞKİ

ÖZ

GİRİŞ ve AMAÇ: Büyük damar oklüzyonu olan akut iskemik inme hastalarında uygulanan mekanik trombektomi (MT) işleminde maruz kalınan radyasyon, hem hasta hem Girişimsel nöroloji uzmanı için riskler oluşturmaktadır. Bu çalışmada; MT uygulanan hastaların maruz kaldığı radyasyon dozu ile anjiografik parametreleri arasındaki ilişki değerlendirilmiştir.
YÖNTEM ve GEREÇLER: 2022 Ocak ve 2022 Aralık tarihleri arasında mekanik trombektomi uygulanan 101 olgu prospektif olarak kaydedilip retrospektif olarak değerlendirildi. Demografik veriler, damar açılma dereceleri, iyi (mRS 0-2) veya kötü (mRS 3-6) klinik sonlanım, anjiografik işlem süreleri ve işlem süresince maruz kalınan radyasyon dozları kaydedilmiştir.
BULGULAR: Ortalama yaş 69,9±13,4 yıl, başvuru Ulusal sağlık inme ölçeği (NIHSS) ortalaması 15,2±5,1 idi. Kasık ponksiyon ile tıkalı damar açılma zaman ortalaması 25,1±15,2, trombektomi geçiş sayı ortalaması 2,1±1,6 ve Radyasyon dozu ortalaması 878,6±555,6 miligraydi. Geçiş sayısı ile hastanın maruz kaldığı radyasyon dozu arasında anlamlı, hafif derecede pozitif korelasyon saptandı (r: 0,196, p<0,05). Kasık ponksiyonu ile tıkalı damarın açılması arasındaki zaman ve hastanın maruz kaldığı radyasyon dozu arasında anlamlı, orta derecede pozitif korelasyonasyon saptandı (r: 0,416, p<0,001).
TARTIŞMA ve SONUÇ: Anjiografik müdahale sırasında maruz kalınan radyasyon dozu hem hekim hem de hasta için çok önemlidir. Kaliteli görüntüyü elde edebileceğimiz optimum anjiografik dozlar belirlenmelidir. İlk geçişte tam rekanalizasyon (mTICI3) hem iyi klinik sonlanım (mRS 0-2) hem de hastanın daha az radyasyona maruz kalmasını sağlamaktadır.

Anahtar Sözcükler: Mekanik trombektomi, radyasyon, akut inme.

INTRODUCTION

Mechanical thrombectomy procedure (1), which should be applied in cerebral large vessel occlusions and has a 1A level of evidence, is performed with X-ray producing angiography devices under fluoroscopy. During the procedure, both the patient and the interventional neurologist are exposed to radiation. Radiation has deterministic (over a certain threshold level) and stochastic (any exposure level) effects (2). A deterministic risk threshold is reached in approximately 6% of patients undergoing mechanical thrombectomy (3). There are radiation-reducing measures (lead apron, thyroid and eye protection) for the interventional neurologist. It is necessary to determine the optimum radiation doses (fluoroscopy pulse rate, DSA frame rates, magnification, and exposure rate) to protect both the patient and the interventional neurologist (4,5). The experience of the interventional neurologist can be considered one of the most important factors in reducing the dose of radiation received. There has been an increase in the number of studies in the last 5 years evaluating the relationship between radiation and mechanical thrombectomy (3,6-8). A single-center, randomized, double-blind, and prospective study also showed that performing the procedure with lower – dose radiation did not change the image quality or procedure time (3). No difference was observed in terms of successful recanalization or a good clinical outcome. Our objective in this study is to evaluate the relationship between the radiation dose exposed to patients undergoing mechanical thrombectomy and angiographic parameters.

METHODS

The study was approved by the Samsun University Clinical Research Ethics Committee (Date: 08.02.2023, No: SÜKAEK-2023-2/16), and the Ethical Principles of the Declaration of Helsinki were followed. The cases that underwent mechanical thrombectomy between January 2022 and December 2022 were recorded prospectively and analyzed retrospectively. Age, gender, medical history (hypertension, diabetes mellitus, atrial fibrillation, smoking, alcohol consumption), NIHSS at admission and occluded vessel, clinical outcome at 3 months (modified Rankin score: mRS) with symptom-recanalization, puncture-recanalization times, and the radiation dose received during the mechanical thrombectomy procedure were recorded. Moreover, the first-pass effect and the number of thrombectomy trials were also recorded. The triaxial system was preferred as the standard approach in the mechanical

thrombectomy procedure. As the thrombectomy technique, either the Solumbra or the ADVANCE technique was utilized. The procedures were performed by the only interventional neurologist at the center. Mechanical thrombectomy procedures were performed with a Siemens Artis Zee Floor monoplane (Erlangen, Germany) angiographic device. Fluoroscopy and DSA were set at 7.5 frames per second and 2.5 frames per second, respectively. The detector radiation dose was set to 55 milligrays (mGy)/pulse in fluoroscopy mode and 3,000 mGy/square for digital subtraction angiography mode (Depending on the weight of the patient, there can be a device-induced change in the radiation dose).

Statistical analysis: After the data obtained from the research were coded, they were analyzed using the SPSS (Version 22.0, SPSS Inc., Chicago, IL, USA) package program. Continuous variables with a normal distribution were reported as mean ± standard deviation, continuous variables with a non-normal distribution were reported as median (minimum-maximum), and categorical data were reported as numbers (%). In the statistical analyses, the conformity of the measurement variables to the normal distribution was evaluated with the Kolmogorov-Smirnov test. Kruskal-Wallis and Mann-Whitney U tests were used to compare continuous variables with a normal distribution. Correlation coefficients were determined using the Spearman correlation test. The statistical significance level was accepted as $p<0.05$ for all tests.

RESULTS

A total of 101 patients (48 females and 53 males), who underwent a mechanical thrombectomy in 2022 and whose radiation doses were recorded, were included in the study. Patients with missing data and whose radiation values were not recorded in the angiography notebook were excluded from the study.

The mean age was 69.9±13.4, the admission national stroke scale score (NIHSS) was 15.2±5.1, symptom onset-to-door time was 241±105.2 minutes, door-to-puncture time was 61.2±15.4 minutes, puncture-to-recanalization time was 25.1±15.2 minutes, the number of pass was 2.1±1.6, and the radiation dose was 878.6±555.6 mGy (fluoroscopy) (859.8±592.1 mGy in MCA M1 occlusion, 1207.1±537.4 mGy in tandem occlusion, 821.6±428 mGy in ICA I,T,L occlusion). Fifty-two patients had middle cerebral artery occlusion, 15 patients had tandem occlusion, and 34 patients had internal carotid artery occlusion (ICA I, T, and L). The rate of good clinical outcome (mRS 0-2) at 3 months was 41.6%. The stroke subtype was cardioembolic in 42.6%, large vessel atherosclerosis in 14.8%, and cryptogenic and other in 42.6%. No correlation was found between age, gender, admission NIHSS scores, and radiation dose. No significant difference was found between the clinical outcome and the radiation dose, between occlusion type and radiation dose, or between stroke subtype and radiation dose ($p>0.05$).

A significant, slightly positive correlation was found between first pass recanalization and radiation dose ($r:0.196$, $p<0.05$). A significant, moderately positive correlation was found between the puncture-recanalization time and radiation dose ($r:0.416$, $p<0.001$).

The radiation dose in patients with a "modified treatment in cerebral ischemia (mTICI)" score of 3 was 799.1±618.8 mGy, the radiation dose in mTICI 2c patients was 1038.4±453.5 mGy, and the radiation dose in mTICI 2b patients was 954.5±427.3 mGy. The radiation dose in patients with a vascular dilatation degree of mTICI3 was statistically significantly lower ($p<0.05$).

DISCUSSION AND CONCLUSION

In our study, radiation exposure was found to be statistically significantly lower in patients with first-pass recanalization, in patients with a short puncture-recanalization time, and in patients with mTICI 3 vascular recanalization ($p<0.05$, $p<0.001$, $p<0.05$, respectively) . No difference was observed between the site of vessel occlusion, stroke subtype, and radiation exposure and the NIHSS.

The radiation emitted in the mechanical thrombectomy procedure performed with X-ray-producing angiography devices may harm the human body. The risk of eye disease (cataract), malignancy, and skin disease increases with cumulative radiation exposure (5,9). With the increase in stroke centers and the number of patients referred to these centers, the number of mechanical thrombectomy procedures and, consequently, interventional neurologists' X-ray exposure have increased in recent years (10).

Despite no side effects were reported related

to X-ray exposure of the patient who underwent thrombectomy or the interventional neurologist who performed the thrombectomy procedure, there have been publications on this subject recently. Relationships between radiation-reducing measures without affecting the quality of the procedure, the thrombectomy technique, and the characteristics of the angiography device and radiation exposure were investigated (3,4,6-9). In our study, neither the physician nor the patient exhibited any radiation-related side effects.

Radiation exposure time is closely associated with the duration of the procedure, the technical difficulty (such as supra aortic vessel tortuosity, aortic arch variations, stenosis/occlusion in the course of the vessel), and the experience of the interventional neurologist (10).

In patients with large vessel occlusion, taking images from both the carotid and dominant vertebral arteries not only increases the exposure to radiation and the contrast material but also delays the recanalization time. If brain tomography or magnetic resonance angiography is performed before the procedure, as collateral evaluation can be performed, other vessels may not be examined during the angiography procedure. Thus, the time exposed to radiation will be reduced. In our clinical practice, we first complete our procedure by reaching the occluded vessel area, yet we also evaluate the Willis polygon in distal ICA occlusions.

Soderman et al. (11) reported 328 Gy.cm2 before the application of radiation reduction measures for endovascular treatments and 109 Gy.cm2 after the application of radiation reduction measures, representing a 67% reduction.

In a study involving 906 patients, the use of a biplane angiographic device resulted in a 15% decrease in the procedure time ($p=0.05$), a 33% reduction in radiation exposure ($p<0.0001$), and a 125% reduction in contrast use ($p<0.0001$) (7). In another study, no relationship was found between stroke severity and radiation dose (6). Farah et al. reported that men were exposed to more radiation, while there was no relationship between age, NIHSS at admission, anterior or posterior system occlusion, or use of a monoplane or biplane angiography device and radiation. Furthermore, unsuccessful recanalization was associated with more radiation exposure than successful recanalization, and the combined technique was associated with more radiation exposure than the stent-retriever technique alone. They also showed that the radiation dose increases with the number of passes (12). A study has shown that performing mechanical thrombectomy using the aspiration technique reduces both the procedure time and the radiation dose (7). In the study of Lapergue et al., multivariate analyses showed that using aspiration or a stent retriever as a mechanical thrombectomy technique did not cause any difference in the duration of radiation exposure (13). We also did not find a relationship between gender, age, stroke severity, stroke subtype, occluded vascular area and exposure to radiation dose. However, less radiation dose exposure was detected in patients with first-pass effects and complete (mTICI 3) vasodilation.

In the study of Cai et al., the radiation dose received in angiography was reported to be 1276.4±1647.5 mGy (1969.3±3119.9 mGy in ICA occlusion, 1031±370.6 mGy in MCA occlusion) (6). It is noteworthy that the radiation dose exposed in our study was lower. We believe that this is due to our experience in neurointerventional procedures, which we have been performing for 6 years as a single operator. In the study of Weyland et al., it was shown that the experience of the physician performing the interventional procedure was associated with less exposure to radiation (7).

Diagnostic dose reference levels, which have already been shown to be effective in controlling exposure and minimizing risks in radiology departments in North America and Europe, were established for diagnostic imaging (14,15).

The study's limitations include the fact that it was conducted at a single site with a small sample size of patients using the Siemens Artis Zee Floor system, which may prevent generalization of the findings. The radiation dose was analyzed only in patients who underwent mechanical thrombectomy. It is known that there may be a relationship between radiation dose and body mass, and evaluations were made without considering this value. Not all angiographic procedures (such as diagnostic angiography, carotid artery stenting, or mechanical thrombectomy) involve the same digital subtraction angiography frame rates, which may affect results.

Therefore, first pass and mTICI3 recanalization should be targeted both to achieve the best clinical outcome and less radiation exposure. Determined dose levels are needed to

receive X-rays at the optimum level for both the physician and the patient in mechanical thrombectomy procedures.

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Ethics

Ethics Committee Approval: The study was approved by Ethics Committee of Samsun University (Date: 08.02.2023, No: SÜKAEK-2023-2/16).

Informed Consent: The authors declared that it was not considered necessary to get consent from the patients because the study was a retrospective data analysis.

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