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Original Scientific Paper

# EVALUATION OF ULTRASONOGRAPHIC ANATOMY OF TRANSVERSUS ABDOMINIS PLANE BEFORE AND AFTER CESAREAN SECTION

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SUMMARY – Transversus abdominis plane (TAP) block is used to provide analgesia after lower abdominal surgery operations. TAP block has been shown to reduce postoperative pain scores and side effects of opioids after cesarean section. Generally, TAP block was introduced after cesarean section. It is assumed that delivery affects sonographic characteristics of the abdominal wall. For this reason, ultrasonographic measurement of the anatomy of the region defined for TAP block was performed before and after cesarean section. It was aimed to determine the estimated TAP block distance in the population undergoing cesarean section. Fifty patients who underwent cesarean section in the operating room were included in the study. The inclusion criteria were ASA score I-II, age 18-45 years, gestational age ≥32 weeks, and cesarean section performed by Pfannenstiel incision. Data on patient age, weight, height, body mass index, gravidity, parity, gestational age (weeks), concomitant disease and allergy were recorded. According to the results obtained in the study, ultrasound should be performed if TAP block is accessible. Before cesarean section, the external oblique muscle and internal oblique muscle are closer to surface than after cesarean section since the TAP distance after pregnancy will be deeper. Systematic data on ultrasonographic anatomy of the abdominal wall in pregnant women have not yet been published. The obstetric anesthesiologist should be aware of these changes when planning a TAP block in the context of cesarean section. There is a need for larger prospective studies.

Key words: *Ultrasonographic anatomy; Transversus abdominis plane; Cesarean section*

## Introduction

Transversus abdominis plane (TAP) block is used to provide analgesia after lower abdominal surgery procedures[1]. TAP block has been shown to reduce postoperative pain scores and side effects of opioids after cesarean section.

The original technique was described by Rafi in the block technique; during passage through the external and internal oblique muscle fascia using the Petit's triangle, local anesthetic is administered to the area. While this approach is known to be effective, some safety issues have arisen, and a new approach has been proposed instead of ultrasonography[2]. The TAP block target are subcostal, ilioinguinal and iliohypogastric nerves[1].

As in all lower abdominal surgery procedures, effective postoperative analgesia has been achieved by TAP block performed after cesarean section. As shown in most studies, the need for opioids or additional analgesics decreased postoperatively[3,4].

Systematic data on the ultrasonographic anatomy of the abdominal wall in pregnant women have not yet been published. Generally, TAP block was introduced after cesarean section. It is assumed that deliv-

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ery affects sonographic characteristics of the abdominal wall. Therefore, ultrasonographic measurements of the anatomy of the region defined for TAP block before and after cesarean section were performed in all women undergoing cesarean section. For subsequent cesarean sections, the estimated TAP block distance in the patient referral population was determined and intended to facilitate patient-oriented treatment.

## Subjects and Methods

Statistical power analysis indicated 48 patients to be needed at 95% confidence level. Fifty women undergoing cesarean section between October 2017 and January 2018 in the hospital operating room were included in the study. Inclusion criteria were as follows: American Society of Anesthesiologists (ASA) score I-II, age 18-45 years, gestational age ≥32 weeks, and cesarean section with Pfannenstiel incision. Patients with emergency cesarean section and patients with median surgical incision were excluded from the study. Demographic data (protocol, age, weight, height, body mass index, gravidity, parity, gestational weeks, additional disease, allergy) appropriate for inclusion criteria were recorded.

Demographic data (age, weight, height, body mass index [BMI]) of all patients were recorded. Patients were tilted 10° to the left to prevent hypotensive syndrome in supine position. Electrocardiogram (ECG), noninvasive arterial blood pressure and peripheral oxygen saturation were monitored according to standard protocol. Both arteries were prehydrated with 500 mL of balanced electrolyte solution. Two standard ultrasonographic examinations were performed by an experienced anesthetist in obstetric anesthesia and TAP blocks using USG device (30 CV portable; Mylab Five Esaote, Geneva, Switzerland) and 36-mm linear US probe 10-18 MHz, used in pregnant women.

The first ultrasound examination was performed just before the induction of anesthesia prior to starting surgery. The transducer was placed under the thoracic cage between the anterior and middle axillary line on the iliac crest, just as in TAP block performed after cesarean section. Vertical distance was measured at the center of the skin still image, with the outer oblique frame, inner oblique frame, transverse abdominus frame and transverse abdominal plane. These measurements were recorded to determine location of the postoperative transverse abdominal plane.

The second examination was performed in the same supine position after all surgical procedures while still in the operation room. If the patient could not lie on the left side, the probe was placed under the iliac crest and under the chest cage between the anterior and middle axillary line, as it had been placed preoperatively. The image stabilized after the optimal image had been achieved. Vertical distance with vertical oblique case, inner oblique case, transverse abdominus case, and transverse abdominal plane was measured and recorded in the skin still image center. There were no invasive interventions in either case. Only the distance was measured with ultrasound and the measurements were recorded. All data were collected by the same anesthesiologist.

The study was approved by the local Ethics Committee (no. 2018/29).

### *Statistical analysis*

The SPSS 15 (Chicago, IL, USA) statistical package was used on statistical analysis of the findings obtained in this study. The Kolmogorov-Smirnov distribution test was used to examine descriptive statistics (frequency, percentage, mean and standard deviation), as well as the normality of distribution of study data. The measurements showed normal distribution. For this reason, parametric methods were preferred. Paired samples t-test was used for two intra-group comparisons of the parameters. On comparison of other data, the independent samples t-test was used in case of two groups, and one-way ANOVA test in case of two or more groups. The results were evaluated at 95% confidence interval, with the level of statistical significance set at $p<0.05$.

## Results

Demographic data of study patients are shown in Table 1. Testing the relationship of age and BMI measurements revealed that BMI increase was parallelled

*Table 1. Demographic data on study patients*

| | Mean ± SD |
|---|---|
| Age (years) | 30.580±5.485 |
| Weight (kg) | 76.620±13.753 |
| Length (cm) | 161.100±5.023 |
| Body mass index (kg/m$^2$) | 29.474±4.932 |
| Gestational age (weeks) | 36.720±2.642 |

SD = standard deviation

by the left external oblique muscle value increase before cesarean section ($p<0.05$). There was no significant relationship between BMI and age and the values of distances measured before and after cesarean section ($p>0.05$ all). The correlations of pre-cesarean and post-cesarean section measurements and gestational weeks are shown in Table 2.

There was no significant correlation between gestational week variables and point averages of the left internal oblique muscle before cesarean section, left

*Table 2. Pre- and post-cesarean measurement and gestational week relationship*

| | | n | Mean | SD | p |
|---|---|---|---|---|---|
| Left external oblique muscle before cesarean section | Preterm | 18 | 7.244 | 1.847 | 0.664 |
| | Term | 32 | 7.538 | 2.478 | |
| Left internal oblique muscle before cesarean section | Preterm | 18 | 11.494 | 2.498 | 0.488 |
| | Term | 32 | 12.175 | 3.673 | |
| Transverse abdominal muscle before cesarean section | Preterm | 18 | 16.944 | 3.186 | 0.258 |
| | Term | 32 | 18.284 | 4.347 | |
| Left transverse abdominal plane distance before cesarean section | Preterm | 18 | 16.772 | 3.008 | 0.292 |
| | Term | 32 | 17.988 | 4.266 | |
| External right oblique muscle before cesarean section | Preterm | 18 | 7.589 | 1.89 | 0.53 |
| | Term | 32 | 8.009 | 2.435 | |
| Right internal oblique muscle before cesarean section | Preterm | 18 | 11.9 | 2.659 | 0.552 |
| | Term | 32 | 12.403 | 2.948 | |
| Right transverse abdominal muscle before cesarean section | Preterm | 18 | 17.617 | 3.858 | 0.522 |
| | Term | 32 | 18.331 | 3.71 | |
| Right transverse abdominal plane distance before cesarean section | Preterm | 18 | 17.45 | 3.799 | 0.571 |
| | Term | 32 | 18.069 | 3.611 | |
| Left external oblique muscle after cesarean section | Preterm | 18 | 7.611 | 2.273 | 0.715 |
| | Term | 32 | 7.866 | 2.391 | |
| Left internal oblique muscle after cesarean section | Preterm | 18 | 12.017 | 2.17 | 0.444 |
| | Term | 32 | 12.666 | 3.163 | |
| Left transverse abdominal muscle after cesarean section | Preterm | 18 | 18.067 | 3.3 | 0.742 |
| | Term | 32 | 18.413 | 3.679 | |
| Left transverse abdominal plane distance after cesarean section | Preterm | 18 | 17.583 | 3.068 | 0.554 |
| | Term | 32 | 18.184 | 3.608 | |
| Right external oblique muscle after cesarean section | Preterm | 18 | 7.994 | 2.243 | 0.736 |
| | Term | 32 | 8.225 | 2.343 | |
| Right internal oblique muscle after cesarean section | Preterm | 18 | 12.8 | 2.863 | 0.668 |
| | Term | 32 | 13.178 | 3.035 | |
| Right transverse abdominal muscle after cesarean section | Preterm | 18 | 18.361 | 3.702 | 0.741 |
| | Term | 32 | 18.719 | 3.618 | |
| Right transverse abdominal plane distance after cesarean section | Preterm | 18 | 18.178 | 3.525 | 0.773 |
| | Term | 32 | 18.488 | 3.674 | |

SD = standard deviation

transverse abdominal muscle before cesarean section, left transverse abdominal plane distance before cesarean section, right external oblique muscle before cesarean section, right internal oblique muscle before cesarean section, right transverse abdominal muscle before cesarean section, left external oblique muscle after cesarean section, left internal oblique muscle after cesarean section, left transverse abdominal muscle after cesarean section, left transverse abdominal plane distance after cesarean section, right external oblique muscle after cesarean section, right internal oblique muscle after cesarean section, right transverse abdominal muscle after cesarean section, and right transverse abdominal plane distance after cesarean section (p>0.05).

One-way variance analysis yielded no significant correlation between cesarean section variables and point averages of the left internal oblique muscle before cesarean section, left transverse abdominal muscle before cesarean section, left transverse abdominal plane distance before cesarean section, right external oblique muscle before cesarean section, right internal oblique muscle before cesarean section, right transverse abdominal muscle before cesarean section, left external oblique muscle after cesarean section, left internal oblique muscle after cesarean section, left transverse abdominal muscle after cesarean section, left transverse abdominal plane distance after cesarean section, right external oblique muscle after cesarean section, right internal oblique muscle after cesarean section, right transverse abdominal muscle after cesarean section, and right transverse abdominal plane distance after cesarean section (p>0.05).

A statistically significant difference was found between the left external oblique muscle before cesarean section and left external oblique muscle after

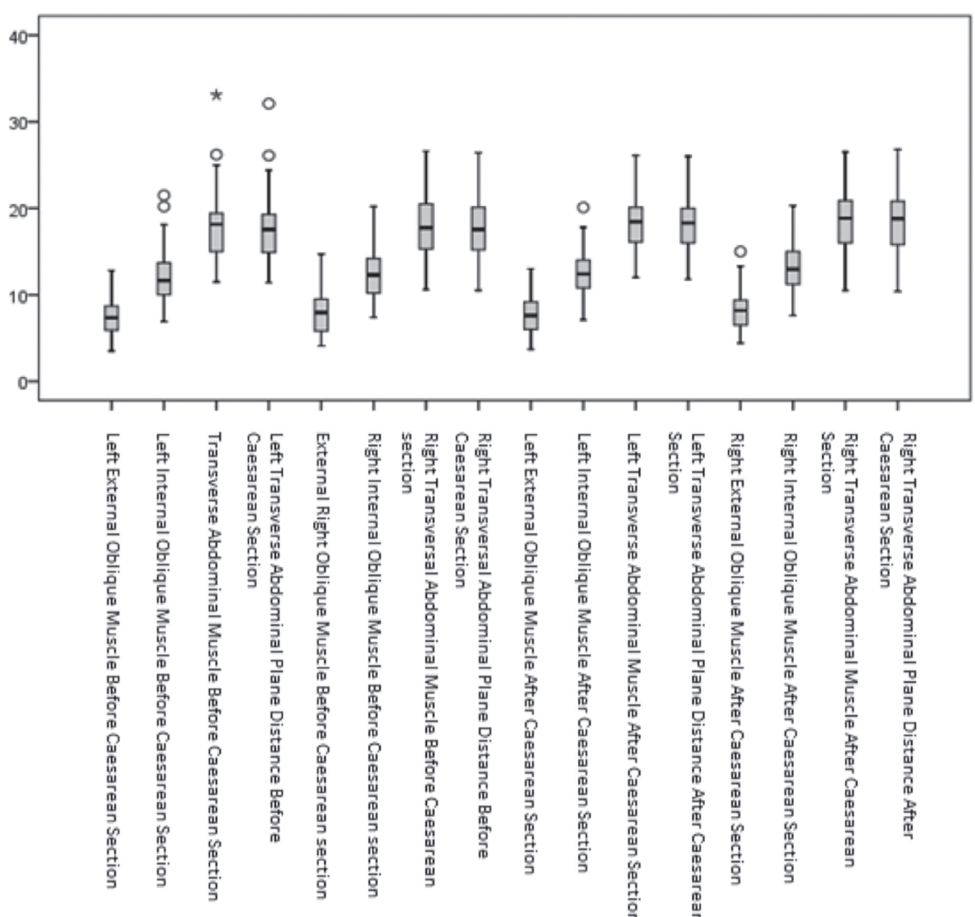


*Fig. 1. Box plot graph for measurements.*

cesarean section, left internal oblique muscle before cesarean section and left internal oblique muscle after cesarean section, right external oblique muscle before cesarean section and right external oblique muscle after cesarean section, right internal oblique muscle before cesarean section and right internal oblique muscle after cesarean section, left external oblique muscle and right external oblique muscle before cesarean section, left external oblique muscle after cesarean section, right external oblique muscle after cesarean section, left internal oblique muscle after cesarean section and right internal oblique muscle after cesarean section ($p>0.05$).

There was no significant difference between averages of the left transverse abdominal muscle before cesarean section and left transverse abdominal muscle after cesarean section, left transverse abdominal plane before cesarean section and left transverse abdominal plane after cesarean section, right transverse abdominal muscle before cesarean section and right transverse abdominal muscle after cesarean section, right transverse abdominal plane before cesarean section and right transverse abdominal plane after cesarean section ($p>0.05$).

There was no significant difference between averages of the left internal oblique muscle before cesarean section and right internal oblique muscle before cesarean section, left transverse abdominal muscle before cesarean section and right transverse abdominal muscle before cesarean section, left transverse abdominal plane before cesarean section and right transverse abdominal plane before cesarean section, left transverse abdominal muscle after cesarean section and right transverse abdominal muscle after cesarean section, left transverse abdominal plane after cesarean section and right transverse abdominal plane after cesarean section ($p>0.05$).

The box plot graph for the right and left side measurements is shown in Figure 1. As seen in the graph, measurements of the external oblique muscle before cesarean section, external oblique muscle after cesarean section and internal oblique muscle right after cesarean section were significantly higher. In other measurements, the right and left side were similar.

After cesarean section, significant increase was observed in the measurements of the left external oblique muscle, left internal oblique muscle, right external oblique muscle and right internal oblique muscle.

## Discussion

Transversus abdominis plane block has been used in various abdominal surgical procedures including cesarean delivery[5-7]. Systematic description of the ultrasonographic anatomy of the TAP region in pregnancies is not available in the literature. In this study, ultrasonographic anatomy of the structures related to pregnant women before and after elective cesarean section was examined. The relevant muscle layers can be seen in all ultrasound examinations performed before and after cesarean section. Before cesarean section, the linear US probe was located near the surface of external and internal abdominal oblique muscles. There was no significant difference in the distance from the transverse abdominal muscle to the surface before and after cesarean section. This finding can be explained by specific changes in the abdominal wall during pregnancy. Since the volume of uterus increases significantly during pregnancy, the circumference of the abdominal wall increases significantly. According to this, the layers of the abdominal wall are under tension and both the submucosal layers and muscle layers become thinner. After cesarean section, this tension is reduced and muscle layer is loose. This may have led to an increase in the depth of muscle layers and a decrease in visibility. It may be misleading when the measurements made before cesarean section are evaluated and prepared for the period after cesarean section. An obstetric anesthetist should be careful in this regard.

Recent studies showed effectiveness of TAP blocks in cesarean section, hysterectomy, cholecystectomy, colectomy, prostatectomy, and hernia repair[9]. TAP block for any surgical procedure can be started before or after the procedure. Given the relatively slow onset of long-acting local anesthesia, pre-surgical TAP block may be potentially beneficial. According to distance between the skin and the TAP region, prepartum administration of TAP block may be a useful strategy. The target plane can be achieved with the needle at a shorter distance before the cesarean section. However, in case of pregnancy, it can be a wrong approach since the fetus can be affected from the local anesthetic applied. Also, systemic toxicity of local anesthetics is a major concern for TAP blocks, thus such a strategy is not suggested. The seizure associated with TAP block was reported 10 minutes after the injection[8]. For this reason, prepartum administration may present an additional risk comparing to postpartum care. Especially local anesthesia toxicities can be hidden in cases of cesarean section under general anesthesia.

A correct database for selecting local anesthetic doses for TAP block has not yet been fully established. Desired local anesthesia is achieved not by injecting a high volume but by gradually changing the needle in the TAP and advancing it. In addition, the concentration of local anesthesia used will determine the duration and intensity of analgesia achieved[10]. For this reason, ultrasound assistance should absolutely be used.

The patient body structures affect the success of regional anesthesia. TAP block may be affected by changes in body weight, fat distribution, muscle and connective tissue structure of the patient. In this study, there was a significant relationship between BMI and TAP distance. Increase in BMI increased the depth of the TAP distance by increasing subcutaneous fat tissue. The depth of TAP depends on body weight. In the case of pregnancies with increased BMI, deeper observation than the average may be expected[11,12]. The patient body weight should be considered when planning a postoperative TAP block. The depth and frequency of the 'transducer' must be adjusted[13,14]. In addition, the choice of needle length should be optimized in this way. If we perform needle and focus selections by looking at TAP distance with preoperative ultrasonography, there may be more time for postoperative preparation. If the anesthetist decides to block the TAP after delivery, it may be useful to perform an ultrasound examination of the abdominal wall preoperatively to minimize the time required to apply the block after surgery. For example, ultrasonic machine settings can be prepared for focal depth and frequency.

McDermott *et al.*[15] evaluated TAP punctures made with a blind technique in the study. While the number of patients targeted in this study was 60, the study was stopped after 36 patients due to a high rate of peritoneal puncture of 13%. In the same study, it was observed that only 23.6% of the correct punches were successful, and even those considered to be experienced could inject into a wrong localization. TAP block with blind technique is not recommended for anesthesiologists who have access to the US clinics.

Baaj *et al.*[3] compared patients treated with bupivacaine and fentanyl with those who underwent cesarean section with spinal anesthesia and those that underwent bilateral TAP block with ultrasonographic guidance compared with the placebo group. In the TAP block group, better postoperative analgesia was achieved, morphine consumption was reduced by 60%, and patient satisfaction was higher than in the placebo group. In this study, the patient did not have a real TAP block and only the measurements performed were scanned. When TAP distance measurements are screened, the same age group of patients who are not pregnant can be compared with the measurements to compare the effects of pregnancy on TAP distance sonoanatomy. In addition, Baaj *et al.*[3] applied spinal anesthesia in their patients. In our study, measurements were taken before preoperative general anesthesia and postoperatively under general anesthesia; thus, the use of neuromuscular agents may have affected measurements.

Eslamian *et al.*[4] compared a group of patients who underwent cesarean section after general anesthesia with those who underwent bilateral TAP with the placebo group. The TAP block group was found to have lower postoperative pain and analgesic consumption compared to the placebo group. They found that the time required for frequent analgesic treatment was longer in the TAP block group. Their study determined Petit's triangle with TAP block blind technique without ultrasound. TAP block without ultrasound may increase the complication rate. In this study, the importance of using ultrasonography to determine TAP plane anatomy was shown. In the present study, TAP plane was clearly visualized with ultrasound.

In a case report published by Miler *et al.*[16], a 23-year-old pregnant patient with a complaint of abdominal pain (visual analog scale, 8/10) and frequent hospital admissions was diagnosed with a distinctive ileocolic lymph node displayed on magnetic resonance imaging. Abdominal pain continued despite increasing intravenous opioid doses (30 mg intravenous hydromorphone *per* day). In the 34$^{th}$ gestational week, a right-sided TAP block catheter containing 0.25% bupivacaine was placed on the ultrasound guiding catheter and this relieved the pain. The patient was treated with 0.5% repeated ropivacaine with TAP catheter, which allowed for complete pain relief within 3 days and complete cessation of opioid medications. The patient was discharged again free of pain. No complications were seen during the pregnancy. Although this study encourages applying TAP blocks during gestational period, the issue requires more patient studies apart from a case report on one patient. When the number of studies increases and the use of ultrasound becomes widespread, catheter placement for TAP block may replace epidural analgesia. Our study was done to learn TAP plane ultrasonography anatomy in pregnancies. This study should be supported with similar studies. Preoperative TAP catheter can be used instead of epidural catheter if pregnant TAP plane anatomy is properly investigated.

There are many studies on TAP block but there is no ultrasonographic study of TAP plane anatomy in our country. In a prospective study performed by Kiefer *et al.*[2], when the TAP block anatomy before and after the 60$^{th}$ gestational cesarean section was examined ultrasonographically, pre-cesarean measurements were found to be significantly lower than the TAP plane distance after cesarean section. In our study, there was no significant result regarding TAP distance when the external and internal muscle distance was significantly lower.

Kiefer *et al.*[2] found the pre-cesarean and post-cesarean TAP distance measurements to be increased in pregnancies with high BMI. The same result was found in our work. An increase in BMI may have deepened TAP distance by increasing abdominal circumference, and such a TAP block may be difficult. The main limitation of this observational sonoanatomical study was that no real TAP block was performed. The data were based solely on metrics.

In conclusion, additional research is needed on sonographic examination of the TAP block anatomy. Ultrasound examination should be performed if the TAP block is accessible. Relevant anatomic sites for TAP block are well visualized sonographically in 100% of cases before and after cesarean section. It may be misleading to scan the anatomy of the TAP block prior to cesarean section because the TAP distance after cesarean section is deeper. The obstetric anesthesiologist should be aware of these changes when planning TAP block in the context of cesarean section.

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Sažetak

## PROCJENA ULTRAZVUČNE ANATOMIJE RAVNINE TRANSVERSUS ABDOMINIS PRIJE I NAKON CARSKOG REZA

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Blok ravnine transversusa abdominisa (transversus abdominis plane, TAP) primjenjuje se za analgeziju nakon abdominalnih kirurških zahvata. Pokazalo se da blokada TAP-a smanjuje poslijeoperacijske bolove i nuspojave opioida nakon carskog reza. Općenito blokada TAP-a počela se primjenjivati kod carskog reza. Smatra se da porođaj mijenja ultrazvučne značajke trbušne stijenke. Zato su ultrazvučna mjerenja anatomije područja definiranog za blokadu TAP-a provedena prije i nakon carskog reza i to kako bi se odredila procijenjena udaljenost blokade TAP-a u populaciji predviđenoj za carski rez. U istraživanje je bilo uključeno 50 žena podvrgnutih carskom rezu u operacijskoj sali. Kriteriji za uključivanje u istraživanje bili su sljedeći: ASA zbroj I.-II., dob 18-45 godina, gestacijska dob ≥32 tjedna i carski rez izveden Pfannenstielovim rezom. Zabilježeni su sljedeći podatci: dob, tjelesna težina i visina, indeks tjelesne mase, graviditet, paritet, gestacijska dob (tjedni), popratne bolesti i alergije. Rezultati ovog istraživanja pokazuju da bi ultrazvučnu procjenu trebalo napraviti ako je blokada TAP-a dostupna. Prije carskog reza vanjski kosi mišić i unutarnji kosi mišić su bliže površini nego nakon carskog reza, jer je udaljenost TAP-a nakon trudnoće dublja. Dosad nisu objavljeni sustavni podatci ultrazvučne anatomije trbušne stijenke kod trudnica. Opstetrijski anesteziolozi trebali bi biti svjesni ovih promjena kad planiraju blok TAP-a u kontekstu carskog reza. Potrebna su daljnja veća prospektivna istraživanja.

Ključne riječi: *Ultrazvučna anatomija; Ravnina transversus abdominis; Carski rez*