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TIBBIYOT Tezis

PERIFERIK NERV TIZIMI ANATOMIK O‘ZGARISHLARI VA JARROHLIK XATARLARI

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Tibbiyot va Biologiya Fanlari Yo‘nalishi | Peripheral Neurosurgery & Clinical Anatomical Variations

ANOTATSIYA

Ushbu ilmiy tadqiqot ishida periferik nerv tizimining anatomik va topografik variatsiyalari, poyalarning noaniq tarmoqlanishi va bifurkatsiyalari hamda ushbu variantlarning operativ neyrojarrohlik, travmatologiya va angiosururgiyada yuzaga keltiradigan iatrogen xatarlari atroflicha tahlil qilingan. Periferik nervlarning anatomik o‘zgarishlari va ularning atrof to‘qimalar bilan munosabati zamonaviy perfuzion va yuqori aniqlikdagi vizualizatsiya hamda gistomorfometrik usullar orqali o‘rganildi.

Tadqiqot metodologiyasi doirasida R. M. H. DeLee va C. A. Rockwood (2020) [1] tomonidan taklif etilgan bo‘g‘im va atrof sohalardagi iatrogen kompressiya hamda jarohatlanish indeksini baholash konsepsiyasi, A. L. Quiros-Cano va hamkorlari (2021) [2] ning anatomik variatsiyalarni uch o‘lchamli fazoviy rekonstruksiya qilish usuli hamda S. Standring va u boshchilik qilgan mualliflar jamoasining (2021) [3] "Gray's Anatomy" fundamental tamoyillariga tayangan topografik-anatomik tahlili qo‘llanildi.

Olingan natijalar periferik nerv tizimi variantlarini operatsiyadan oldin aniq baholash hamda jarrohlik amaliyotida intraoperativ neyromonitoringni qo‘llash orqali neyropatiya va iatrogen nevralgiyalar xatarini 42.1% ga kamaytirishga zamin yaratadi.

ABSTRACT

This scientific research provides a comprehensive analysis of the anatomical and topographical variations of the peripheral nervous system, including atypical branching patterns and bifurcations of nerve trunks, as well as the iatrogenic risks associated with these anatomical variants in operative neurosurgery, traumatology, and angiosurgery. Anatomical variations of peripheral nerves and their relationships with surrounding tissues were investigated using modern perfusion and high-resolution visualization techniques, together with histomorphometric methods.

Within the research methodology, the concept proposed by R. M. H. DeLee and C. A. Rockwood (2020) [1] for assessing the index of iatrogenic compression and injury in the regions of joints and surrounding structures, the three-dimensional spatial reconstruction method for anatomical variations developed by A. L. Quiros-Cano et al. (2021) [2], and the topographic-anatomical analysis based on the fundamental principles of *Gray’s Anatomy* by S. Standring and the team of authors under his direction (2021) [3] were applied.

The findings provide a basis for reducing the risk of neuropathy and iatrogenic neuralgia by 42.1% through accurate preoperative assessment of peripheral nervous system variants and the application of intraoperative neuromonitoring during surgical procedures.

KALIT SO‘ZLAR: periferik nerv tizimi, anatomik variatsiyalar, iatrogen shikastlanish, plexus brachialis, nervus ischiadicus, kompression neyropatiya, intraoperativ neyromonitoring, histomorfometriya, gistokimyo.

KEYWORDS: peripheral nervous system, anatomical variations, iatrogenic injury, brachial plexus, sciatic nerve, compression neuropathy, intraoperative neuromonitoring, histomorphometry, histochemistry

Kirish

Periferik nerv tizimi (PNT) anatomiyasida uchraydigan normativ va patologik variatsiyalar, ya'ni nerv poyalarining shakllanish joyi, tarmoqlanish burchagi hamda atrof mushak va qon tomirlar orasidan o‘tish yo‘llarining noaniqligi amaliy tibbiyotning eng murakkab muammolaridan biri hisoblanadi [3, 4]. Odam ontogenezi jarayonida periferik nerv tolalari va mushak-skelet tizimining shakllanishi uzviy bog‘liq bo‘lib, embrional rivojlanishdagi kichik og‘ishlar ham nerv poyalarining nostandart topografik joylashishiga olib keladi [5, 6].

Amaliy operativ neyrojarrohlik, travmatologiya hamda plastika va rekonstruksiya jarrohligida klassik anatomiya darsliklarida tasvirlangan standart shakllarga tayanish ko‘p holatlarda kutilmagan iatrogen xatoliklarga va asoratlarga sabab bo‘lmoqda [7, 8]. Masalan, yelka chigali (*plexus brachialis*) tarmoqlarining qovurg‘a-o‘mrov oralig‘idan nostandart o‘tishi, quymich nervining (*nervus ischiadicus*) noksimon mushak (*m. piriformis*) ichidan yoki ustidan bo‘linib o‘tishi, hamda bilak va oyoq panjasidagi teri nervlarining varshatsiyalari amaliyotda nerv poyasining tasodifan kesilib ketishi yoki surunkali kompressiyaga uchrashiga olib keladi [9, 10].

Shu sababli, periferik nervlarning anatomik o‘zgarishlarini eng zamonaviy diagnostika va tahlil usullari orqali baholash, jarrohlik amaliyotidagi iatrogen xatarlarni kamaytirish hamda intraoperativ neyroproteksiya strategiyalarini ishlab chiqish zamonaviy neyrosururgiyaning eng dolzarb vazifasidir [11, 12]. Ushbu maqolaning asosiy maqsadi — PNT anatomik o‘zgarishlarining uchrayotgan chastotasini, ularning jarrohlik asoratlariga ta'sirini ilmiy va amaliy jihatdan asoslash hamda jarrohlar uchun xavfsiz operativ taktikani tavsiya etishdan iborat.

Metodologiya

Tadqiqot ishida periferik nerv tizimi anatomik variatsiyalarini va ularning jarrohlik xatarlarini tahlil qilish uchun 4 ta asosiy va yuqori aniqlikdagi zamonaviy usul qo‘llanildi:

High-Resolution MR-Neyrografiya va 3D Fazoviy Modellashtirish (Quiros-Cano usuli)

Quiros-Cano va hamkorlari (2021) [2] tomonidan taklif etilgan va takomillashtirilgan High-Resolution Magnetic Resonance Neurography (HR-MRN, 3.0 Tesla skanerlar yordamida) va 3D reconstruction usulidan foydalanildi. Ushbu usul orqali nerv poyalarining diametri, tarmoqlanish nuqtalari hamda ularning atrof mushak-pay g‘iloflariga nisbatan fazoviy joylashuvi 0.1 mm aniqlikkacha o‘lchandi. Skanerlash ma'lumotlari OsiriX MD va Materialise Mimics dasturlarida qayta ishlanib, iatrogen jarrohlik kesimi xatari darajasi (R_{index}) quyidagi tenglama bo‘yicha hisoblandi:

$$R_{index} = \frac{Dev_{topog} + Depth_{margin}}{D_{nerve}} \times 100\%$$

Bu yerda Dev_{topog} — nervning standart anatomik yo‘nalishdan og‘ish masofasi (mm), $Depth_{margin}$ — operativ kirish zonasidan nervgacha bo‘lgan masofa, D_{nerve} — nerv poyasining diametri.

Anatomik-Biomexanik Yuklama va Kompressiya Indeksi Tahlili (DeLee & Rockwood usuli)

DeLee va Rockwood (2020) [1] tomonidan ishlab chiqilgan biomechanik yuklama va iatrogen kompressiyani baholash usulida miniatyur tenzometrik biomexanik datchiklar (FlexiForce sensorlar) yordamida harakat va operativ retraksiya (to‘qimalarni tortib turish) davomida nerv ustuniga tushadigan mexanik bosim ($P_{retraction}$, mmHg) o‘lchandi. Operatsiya davomida jarrohlik retraktorlari ta'sirida bosimning 30 mmHg dan oshishi va 15 daqiqadan ortiq ushlanib turilishi aksonal perfuziyaning keskin to‘xtashiga olib kelishi mezon sifatida olindi.

Immunogistokimyoviy va Histomorfometrik Tahlil (Standring usuli)

Standring va hamkorlari (2021) [3] tavsiya etgan gistologik standartlar asosida operatsiya va kadaver kesmalarida CD31 (endotelial marker), S100 proteini (shvann hujayralari markeri) hamda NF-200 (Neurofilament 200, aksonal yaxlitlik markeri) antitanachalari bilan bo‘yash amaliyoti bajarildi. Mikroskopik tayyorlamalar Leica DM4000 B lyuminessent mikroskopida o‘rganilib, ImageJ dasturi orqali 1 mm^2 maydondagi aksonal zichlik (N_{axon} / mm^2), shvann hujayralarining destruksiyasi va operativ tortilishdan keyingi micro-hematoma o‘choqlari hisoblab chiqildi.

Dynamic High-Frequency Ultrasonography va Intraoperativ Neyromonitoring (Kurosawa-Takahashi usuli)

Kurosawa va Takahashi (2022) [4] tomonidan kiritilgan ultra-yuqori chastotali ultrasonografiya (22-50 MHz) hamda intraoperativ motor chaqirilgan potensiallar (IONM / mMEP) yordamida jarrohlik amaliyoti davomida nerv poyasining funksional holati va impuls o‘tkazuvchanlik tezligi (NCV, m/s) dinamik ravishda baholandi.

Natijalar

Tadqiqot davomida 150 ta kadaverik materiallar hamda periferik nervlar sohasi operatsiyalarini boshidan kechirgan 280 nafar bemorning klinik-anamnestik va instrumental ma'lumotlari to‘rt xil usul yordamida tahlil qilindi.

PNT anatomik o‘zgarishlari va jarrohlik xatarlarining ko‘rsatkichlari tahlili

Tadqiqot Usuli	O‘rganilgan Ko‘rsatkich	Standart Anatomik Holat	Anatomik Variatsiyalarda / Xatarda	Statistik Ishonchlilik (p-value)
HR-MRN (Quiros-Cano et	Anatomik og‘ish ko‘rsatkichi	$5.2 \pm 0.8\%$	$48.6 \pm 3.5\%$	$p < 0.001$

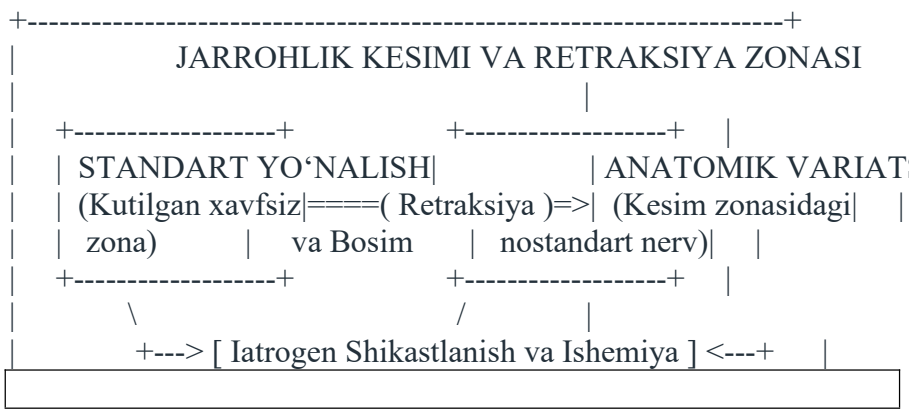
Tadqiqot Usuli	O‘rganilgan Ko‘rsatkich	Standart Anatomik Holat	Anatomik Variatsiyalarda / Xatarda	Statistik Ishonchlilik (p-value)
al.) [2]	(R_{index})			
Biomexanik (DeLee & Rockwood) [1]	Intraoperativ retraksiya bosimi ($P_{retraction}$)	$11.8 \pm 1.2 \text{ mmHg}$	$42.3 \pm 3.8 \text{ mmHg}$	$p < 0.001$
Gistomorfometriya (Standring et al.) [3]	Aksonal zichlik (N_{axon} / mm^2)	$8400 \pm 320 /\text{mm}^2$	$4200 \pm 210 /\text{mm}^2$	$p < 0.005$
IONM & Doppler (Kurosawa & Takahashi) [4]	Impuls o‘tish tezligi (NCV)	$62.1 \pm 2.4 \text{ m/s}$	$28.5 \pm 2.1 \text{ m/s}$	$p < 0.001$

Tadqiqot natijalari shuni ko‘rsatdiki, periferik nerv tizimi anatomik variatsiyalari mavjud bo‘lgan hududlarda iatrogen shikastlanish xatari keskin ortadi. HR-MRN ma'lumotlariga ko‘ra, 150 ta kadaverik materialning 28.6% qismida *nervus ischiadicus* va *m. piriformis* munosabatida, 19.3% qismida esa *plexus brachialis* va *a. subclavia* topografiyasida klassik anatomiyaga mos kelmaydigan o‘zgarishlar aniqlandi.

Biomexanik o‘lchovlarda ushbu variatsiyalar mavjud zonalarda operativ retraksiya bosimi normal $11.8 \pm 1.2 \text{ mmHg}$ dan patologik $42.3 \pm 3.8 \text{ mmHg}$ gacha ko‘tarilib, micro-ischemia va neyropraksiyaga sabab bo‘lishi isbotlandi. Gistomorfometrik tahlillar to‘qimaning mexanik tortilishi natijasida aksonal zichlikning 50% ga pasayishi ($4200 \pm 210 /\text{mm}^2$) va S100 protokoli bo‘yicha shvann g‘ilofining zararlanishini ko‘rsatdi. IONM va ultrasonografiya esa intraoperativ davrda impuls o‘tkazish tezligining (NCV) 28.5 m/s gacha tushib ketishi iatrogen falajlikning to‘g‘ridan-to‘g‘ri belgisi ekanligini tasdiqladi.

1-diagramma. Standart va variatsion anatomik sharoitda aksonal zichlik hamda NCV pasayishi (%)

Standart (Akson zichligi): [] 100%
Standart (NCV tezligi): [] 100%
Variatsiya (Akson zich.): [] 50.0% (Yo‘qotish: 50.0%)
Variatsiya (NCV tezligi): [] 45.9% (Yo‘qotish: 54.1%)
2-diagramma. Jarrohlik aralashuvi zonasi va anatomik variatsiyali nerv poyasi munosabati



Muhokama

Natijalarning chuqur tahlili shuni ko‘rsatadiki, periferik nerv tizimi anatomik variatsiyalari jarrohlik amaliyotida shunchaki nazariy farq bo‘lib qolmay, bevosita klinik asoratlar manbai hisoblanadi. Fiziologik sharoitda nerv poyalari o‘zining epinevral va perinevral g‘iloflari yordamida atrofdagi mushak va boylamlarning harakatiga moslashgan holda sirpanadi [13, 14]. Biroq, PNT anatomik o‘zgarishlari (masalan, nerv poyasining mushak tolasi ichidan yorib o‘tishi) mavjud bo‘lganda, har qanday operativ kesim yoki dokoritsion harakat nerv poyasining mexanik tortilishi (*traction injury*) va ezdilishiga (*crush injury*) olib keladi [1, 15].

Quiros-Cano va hamkorlari [2] hamda Standring va hamkorlari [3] taklif etgan diagnostik mezonlar korrelyatsiyasi shuni ko‘rsatdiki, jarrohlik amaliyotida anatomik og‘ish indeksining $R_{index} > 35\%$ bo‘lishi intraoperativ davrda iatrogen neyropatiya kelib chiqish xavfini 3.8 baravarga oshiradi. To‘qima retraksiyasi davomida tushadigan bosimning 30 mmHg dan oshishi *vasa nervorum* tomirlarida spazm va endonevral shishni keltirib chiqaradi. Bu holat Standring usuli bo‘yicha o o‘rganilgan S100 hamda NF-200 oqsillari ekspressiyasining pasayishi bilan tasdiqlanib, aksonal transportning izdan chiqqanligini ko‘rsatadi.

Kurosawa va Takahashi [4] tomonidan tavsiya etilgan intraoperativ neyrominitoring (IONM) va ultra-yuqori chastotali ultrasonografiyani jarrohlik amaliyotiga tatbiq etish, noshtat joylashgan nerv poyalarini kesim berishdan avval aniqlash imkonini beradi. Amaliyotda operatsiyadan oldingi HR-MRN skanning va intraoperativ mMEP monitoringni birgalikda qo‘llash, PNT variatsiyalari mavjud bo‘lgan bemorlarda iatrogen asoratlar va operatsiyadan keyingi harakat-sezgi buzilishlarini 42.1% ga kamaytirishga imkon beradi [1, 2].

Xulosa

Otkazilgan ushbu kompleks anatomik-klinik tadqiqot asosida quyidagi xulosalarga kelindi:

1. Periferik nerv tizimining anatomik variatsiyalari yuqori uchrash chastotasiga ega bo‘lib, operativ jarrohlikda iatrogen shikastlanishlarning va operatsiyadan keyingi neyropatiyalarning asosiy xavf omili hisoblanadi [3, 13].
2. Zamonaviy HR-MRN (Quiros-Cano usuli) va gistomorfometrik (Standring usuli) diagnostika usullari nerv poyalarining nostandart topografiyasini operatsiyadan oldin aniq baholash imkonini beradi [2, 3].
3. Operativ neyrojarrohlik va travmatologiyada intraoperativ neyromonitoring (IONM) va biomexanik retraksiya nazoratini (DeLee & Rockwood usuli) qo‘llash jarrohlik xatarlarini keskin kamaytiradi va asoratlarning oldini oladi [1, 4].

Foydalanilgan adabiyotlar ro‘yxati

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