Facet pain syndrome. Underlaying mechanisms of acute stage with thoracic spinal unit example

The fixed small thoracic vertebra dislocation has been modeled on animals (rabbits) to simulate the biomechanics changes revealed on X-ray images (illustrated) in patients with thoracic zygapophyseal joints arthralgia. Involved spinal motional unit’s tissues were investigated by light microscopy after 7 and 14 days. The most reactive tissue was the fold of a capsule’s synovial membrane inside zygaphyseal joint. Densely innervated by myelinated and unmyelinated nerve fibers synovial fold has been enlarged in average more than double as a result of edema and it was pinched closely between zygaphyseal facets. The intact synovial fold is presented for comparison. Specific changes of neural cell’s pools in substantia gelatinosa of Rolando and cells in lateral horn (sympathetic neural centers) of spinal cord gray matter were arose simultaneously on the level corresponded to displaced zygapophysal joints. Described mechanism triggers nociceptive afferentation from a swollen and squeezed synovial fold receptors with the facet pain syndrome of biomechanics nature.

Key words: facet pain syndrome, zygaphophysal joints, synovial membrane, synovial fold of zygaphyseal joint’s capsule, dorsalgalgia, nociceptive spinal reaction.

Introduction

Facet syndrome (FS) with back pain has been discussed more than 100 years (Goldwaith J.E., 1911; Giles I.G.F., Taylor J.R., 1987) and described as a chronic lumbar spinal pain caused by pathologies of a zygaphophysal joints (Baster T., 2012). It is considered as a result of numerous potential causes of pain: the age-related degenerative impairment of intervertebral disc, spondyloarthrosis, muscle- or ligament-related injuries etc. (Cohen S.P., Raja S.N., 2007). However, the processes within the specific anatomical structures of Z-joints, which produce the irritation of pain affereents signaling with FS of biomechanics nature have not been enough illustrated to date. We have not found convincing study results concerning mechanisms of pain involved in FS on the thoracic level in spite of certain attempts to solve the problem and related intensive discussing (Baster T., 2012).

There is a set of nonsurgical effective approaches in FS treatment including the local medicine blockade (Manchikanti L. et al., 2012), exposure to extreme low temperature (cryoablation), high temperature radiofrequency and chemical neurolysis, radiofrequency ablation (Soloman M. et al., 2010). The basic point of action of the methods mentioned above is a facet denervation — to affect nerves supplying periarticular and articular tissues. So, this is an evidence for the nociceptive afferentation from zygaphophysal joints. However, these facts do not explain, which exact anatomical structures are responsible for the irritation of the pain affereents.

Analysis of the thoracic X-ray images in 340 patients with nonspecific middle back pain have showed that biomechanical deviations in spinal unit were more frequent than degenerative disorders: 59.06% and 40.94%, respectively (Gongalsky V.V., 1994; 2014). This study did not involve the patients with any inflammatory signs of spondyloarthритis or spondylitis; inclusive criteria suggested negative inflammatory tests (rheumatic tests, inflammation blood and urine markers). The herniation of the thoracic disc, spinal stenosis, any sort of malformations, osteoporosis, neoplastic processes, wedge-shaped deformation of the vertebrae, vertebrae or ribs fractures and any other kind of pathology which could be cause of spinal pain were excluded. Polyradicul and pyramidal neurological signs were not present in studied patients. The study has shown (Gongalsky V.V., 1994; 2014) that involved functional spinal unit (FSU), verified clinically as a "painful", had common specific biomechanical characteristics in most cases: asymmetry of the intervertebral gap; slight lateral displacement of the vertebra; sign of lateral deviation of the spinous process (Fig. 1). Combination of these three revealed shifts in FSU was considered as a minimal fixed rotational displacement of the thoracic vertebra with a within the range than slightly exceeded physiological limits.

Objective

The objective of the study was to verify exact structures in thoracic zygaphophysal joints, which can source of nociceptive afferentation in a pain FS of biomechanics nature.

Materials and methods

The fixed small rotational displacement of the vertebra, which had been revealed with radiographic examinations of patients with nonspecific thoracic back pain was modelled on rabbit thoracic spine (Fig. 2) (Gongalsky V.V., Tulinova E.V., 1987). Protocol of the experimental study was approved by the institutional Animal Care Ethic Committee of National Medical University named after O.O. Bohomolets.
Changes in acute stage of FS is shown on Fig. 4. The intact synovial fold is shown for comparison.

On the 14th day of the experiment the synovial fold was still edematous and enlarged but less tightly wedged between zygapophyseal articular processes (Fig. 5). Morphological picture corresponds to subacute stage of FS.

Described inflammatory changes of the synovia fold were regressing gradually even in maintained subluxation. The histological signs of another different causes of spinal pain had been occurring gradually up to 168th day of the study (approximately within 6 months), forming some different chronic causes of spinal pain.

Discussion

Biomechanics of a thoracic spine is rather complicated. There are some basic movements in a thoracic FSU: flexion and extension in a sagittal plane, rotation in a horizontal plain and a slight tilt in a frontal plain. These movements are proceeding simultaneously to provide physiological mobility in thoracic FSU. Physiological ranges of movements in each thoracic FSU are minimal. The required mobility of the entire thoracic spine is provided by the sum of numerous independent small movements of each FSU. Described movements are physiological, painless and not traumatic.

Analysis of spinal areas on the level of dorsalgia by X-ray images assessment has shown the common specific biomechanical deviations in FSU which were detected more often than degenerative abnormalities (Gongalsky V.V., 2014). The most important of them were the slight lateral displacement of a vertebra and lateral deviation of the spinous process. The phenomenon of lateral deviation of the spinous process has been discussed in the article. The image corresponds to subacute stage of FS.

On the 14th day of the experiment the synovial fold was still edematous and enlarged but less tightly wedged between zygapophyseal articular processes (Fig. 5). Morphological picture corresponds to subacute stage of FS.

Described inflammatory changes of the synovia fold were regressing gradually even in maintained subluxation. The histological signs of another different causes of spinal pain had been occurring gradually up to 168th day of the study (approximately within 6 months), forming some different chronic causes of spinal pain.

Described inflammatory changes of the synovia fold were regressing gradually even in maintained subluxation. The histological signs of another different causes of spinal pain had been occurring gradually up to 168th day of the study (approximately within 6 months), forming some different chronic causes of spinal pain.

Described inflammatory changes of the synovia fold were regressing gradually even in maintained subluxation. The histological signs of another different causes of spinal pain had been occurring gradually up to 168th day of the study (approximately within 6 months), forming some different chronic causes of spinal pain.

Described inflammatory changes of the synovia fold were regressing gradually even in maintained subluxation. The histological signs of another different causes of spinal pain had been occurring gradually up to 168th day of the study (approximately within 6 months), forming some different chronic causes of spinal pain.

Discussion

Biomechanics of a thoracic spine is rather complicated. There are some basic movements in a thoracic FSU: flexion and extension in a sagittal plane, rotation in a horizontal plain and a slight tilt in a frontal plain. These movements are proceeding simultaneously to provide physiological mobility in thoracic FSU. Physiological ranges of movements in each thoracic FSU are minimal. The required mobility of the entire thoracic spine is provided by the sum of numerous independent small movements of each FSU. Described movements are physiological, painless and not traumatic.

Analysis of spinal areas on the level of dorsalgia by X-ray images assessment has shown the common specific biomechanical deviations in FSU which were detected more often than degenerative abnormalities (Gongalsky V.V., 2014). The most important of them were the slight lateral displacement of a vertebra and lateral deviation of the spinous process. The phenomenon of lateral deviation of the spinous process has been discussed in the article. The image corresponds to subacute stage of FS.

On the 14th day of the experiment the synovial fold was still edematous and enlarged but less tightly wedged between zygapophyseal articular processes (Fig. 5). Morphological picture corresponds to subacute stage of FS.

Described inflammatory changes of the synovia fold were regressing gradually even in maintained subluxation. The histological signs of another different causes of spinal pain had been occurring gradually up to 168th day of the study (approximately within 6 months), forming some different chronic causes of spinal pain.

Discussion

Biomechanics of a thoracic spine is rather complicated. There are some basic movements in a thoracic FSU: flexion and extension in a sagittal plane, rotation in a horizontal plain and a slight tilt in a frontal plain. These movements are proceeding simultaneously to provide physiological mobility in thoracic FSU. Physiological ranges of movements in each thoracic FSU are minimal. The required mobility of the entire thoracic spine is provided by the sum of numerous independent small movements of each FSU. Described movements are physiological, painless and not traumatic.

Analysis of spinal areas on the level of dorsalgia by X-ray images assessment has shown the common specific biomechanical deviations in FSU which were detected more often than degenerative abnormalities (Gongalsky V.V., 2014). The most important of them were the slight lateral displacement of a vertebra and lateral deviation of the spinous process. The phenomenon of lateral deviation of the spinous process has been discussed in the article. The image corresponds to subacute stage of FS.

On the 14th day of the experiment the synovial fold was still edematous and enlarged but less tightly wedged between zygapophyseal articular processes (Fig. 5). Morphological picture corresponds to subacute stage of FS.

Described inflammatory changes of the synovia fold were regressing gradually even in maintained subluxation. The histological signs of another different causes of spinal pain had been occurring gradually up to 168th day of the study (approximately within 6 months), forming some different chronic causes of spinal pain.

Discussion

Biomechanics of a thoracic spine is rather complicated. There are some basic movements in a thoracic FSU: flexion and extension in a sagittal plane, rotation in a horizontal plain and a slight tilt in a frontal plain. These movements are proceeding simultaneously to provide physiological mobility in thoracic FSU. Physiological ranges of movements in each thoracic FSU are minimal. The required mobility of the entire thoracic spine is provided by the sum of numerous independent small movements of each FSU. Described movements are physiological, painless and not traumatic.

Analysis of spinal areas on the level of dorsalgia by X-ray images assessment has shown the common specific biomechanical deviations in FSU which were detected more often than degenerative abnormalities (Gongalsky V.V., 2014). The most important of them were the slight lateral displacement of a vertebra and lateral deviation of the spinous process. The phenomenon of lateral deviation of the spinous process has been discussed in the article. The image corresponds to subacute stage of FS.

On the 14th day of the experiment the synovial fold was still edematous and enlarged but less tightly wedged between zygapophyseal articular processes (Fig. 5). Morphological picture corresponds to subacute stage of FS.

Described inflammatory changes of the synovia fold were regressing gradually even in maintained subluxation. The histological signs of another different causes of spinal pain had been occurring gradually up to 168th day of the study (approximately within 6 months), forming some different chronic causes of spinal pain.

Discussion

Biomechanics of a thoracic spine is rather complicated. There are some basic movements in a thoracic FSU: flexion and extension in a sagittal plane, rotation in a horizontal plain and a slight tilt in a frontal plain. These movements are proceeding simultaneously to provide physiological mobility in thoracic FSU. Physiological ranges of movements in each thoracic FSU are minimal. The required mobility of the entire thoracic spine is provided by the sum of numerous independent small movements of each FSU. Described movements are physiological, painless and not traumatic.

Analysis of spinal areas on the level of dorsalgia by X-ray images assessment has shown the common specific biomechanical deviations in FSU which were detected more often than degenerative abnormalities (Gongalsky V.V., 2014). The most important of them were the slight lateral displacement of a vertebra and lateral deviation of the spinous process. The phenomenon of lateral deviation of the spinous process has been discussed in the article. The image corresponds to subacute stage of FS.

On the 14th day of the experiment the synovial fold was still edematous and enlarged but less tightly wedged between zygapophyseal articular processes (Fig. 5). Morphological picture corresponds to subacute stage of FS.

Described inflammatory changes of the synovia fold were regressing gradually even in maintained subluxation. The histological signs of another different causes of spinal pain had been occurring gradually up to 168th day of the study (approximately within 6 months), forming some different chronic causes of spinal pain.

Discussion

Biomechanics of a thoracic spine is rather complicated. There are some basic movements in a thoracic FSU: flexion and extension in a sagittal plane, rotation in a horizontal plain and a slight tilt in a frontal plain. These movements are proceeding simultaneously to provide physiological mobility in thoracic FSU. Physiological ranges of movements in each thoracic FSU are minimal. The required mobility of the entire thoracic spine is provided by the sum of numerous independent small movements of each FSU. Described movements are physiological, painless and not traumatic.

Analysis of spinal areas on the level of dorsalgia by X-ray images assessment has shown the common specific biomechanical deviations in FSU which were detected more often than degenerative abnormalities (Gongalsky V.V., 2014). The most important of them were the slight lateral displacement of a vertebra and lateral deviation of the spinous process. The phenomenon of lateral deviation of the spinous process has been discussed in the article. The image corresponds to subacute stage of FS.

On the 14th day of the experiment the synovial fold was still edematous and enlarged but less tightly wedged between zygapophyseal articular processes (Fig. 5). Morphological picture corresponds to subacute stage of FS.

Described inflammatory changes of the synovia fold were regressing gradually even in maintained subluxation. The histological signs of another different causes of spinal pain had been occurring gradually up to 168th day of the study (approximately within 6 months), forming some different chronic causes of spinal pain.
has been described and even declaratively patented (Suvak V.V., 1982). According to our investigations (Gongalsky V.V., 1994; 2014), the deviation of the spinous process becomes clinically significant in case of a vertebra rotation in a range extended a little more than physiological (Gongalsky V.V., 2014). This deviation accompanied by specific clinical signs: rotation of the spinous process was a locally painful in palpation as well as painful regions over zygapophysial joints in paravertebral zones.

It is important to notice that the degenerative signs were presented not only in affected FSU but also in intact (‘painless’) spinal segments to the same extent.

Modelling of the rotational thoracic vertebra displacement on a human spine specimen without soft tissues showed that the maximal angle of rotation of the thoracic vertebra in horizontal plane was 5° (Gongalsky V.V., 1994). In case of intact soft tissues in FSU, the range of this motion was decreased substantially up to 2–3° (Gongalsky V.V., 1994). D.I. Maiman and F.A. Pintar (1992) described the maximal angle of the thoracic vertebra rotation as 9°. According to our data, the angle of vertebral rotation is possible, but in case of exceeding rotation which is more than physiological. It is possible only with additional lateral tilt of a vertebra body coupled with its side small displacement. There are some available data (Maiman D.I., Pintar F.A., 1992) affirmed the side thoracic vertebra tilt. According to our data (Gongalsky V.V., 1994), separated side tilt in that range is not possible without accompanied extra rotation. This two biomechanics factors lead to asymmetry of inter-vertebral gap (the second X-ray sign). The third sign is a local asymmetrical banding in a spinal unit (Gongalsky V.V., 1994). The total sum of described movements provides the thoracic vertebra extra rotation. So, this kind of a thoracic vertebral extra rotation detected in frontal X-ray images has integrated sign — small extra deviation of spinous process.

Extra deviation of a spinous process can differ in its range. It is possible to locate it, for example, in a top or in a beginning of scoliotic arc. Solitary vertebra displacement may happen during overload of a spine: in lifting of heaviness, during awkward movement or being in uncomfortable posture. In any case, the side deviation of spinous process coupled with painful areas and mentioned X-ray signs indicate FSU instability with biomechanical reaction of zygapophyseal joints in the form of asymmetry facets dislocation.

The fold of a synovial membrane is located in joints cavity and does not prevent movements of joint in physiological range. But, in over-dislocation of facets, the synovial fold reacts rapidly with edema. Inflamma ted synovial fold becomes nonflexible body. It gets wedged between joint facets and prevents further joint motion. Thus, it’s possible to assume that rapid enlargement of synovial fold is a protective reaction aimed to prevent mechanically further facets motion and more serious trauma. Synovial membrane is abundantly innervated by thinly myelinated and unmyelinated nerves trunks (Wyke B., 1972) and endings around vascular plexuses (Mapp P.I., 1995). The most significant are the articular receptors of IV Type category embraces the non-capillary nerve endings in joint tissues, being represented by lattice-like plexus and free nerve endings. IV Type plexus system is a distinctive neural representative for fibrous tissue of zygapophyseal capsule. Plexus nociceptively informs us about deformation or stretching of the capsule together with the III Type very slowly adapting endings in ligament attachments to a bone. All capsule receptors and intra-capsule nerves are anatomically connected with vessels (Wyke B., 1972) and should respond to inflammation of the capsule synovial membrane in over-stretching and capsular tissue inflammation. This is the most possible reason of developing pathological nociceptive (pain) afferentation from receptors in swollen synovia fold.

The evidence of pain appearance has been expressed with specific neural cells reaction in substantia gelatinosa of Rolando (Gongalsky V.V., 1994) and in lateral horn (Gongalsky V.V., 1994) of spinal cord gray matter on the level related to the FSU with dislocated vertebra. Substantia gelatinosa controls pain signaling (Petras J.M., 1968). The neural cells reaction in a lateral horn of medulla spinalis (sympathetic centers) is evidence of well known sympathetic tinge of vertebral pain.

Conclusions

The cause of pain in FS of biomechanics nature is a trauma of zygapophyseal joint soft tissues in a small over-range motion of the facets and fixed them in dislocated position. Even small trauma resulted from an awkward body movement or being in uncomfortable posture may produce the same over-dislocation in FSU where zygapophyseal joint fold of synovial membrane responds first. Synovial membrane of thoracic zygapophyseal joints is a reactive tissue which is capable to enlarge immediately by inflammation in trauma even due to the slight movements of spinal motional unit. This is the one of compensatory mechanism to block a spinal unit for preventing further dislocation of the facets and more serious impairment. The synovial membrane is innervated by thinly myelinated and unmyelinated nerve fibers. This is the reason of arising nociceptive afferentation out of receptors from swollen and squeezed synovial fold. Thrombophlebitis process is a result of irritated segmental neural fibers which supply zygapophyseal joints within one segmental sclerocence. Specific changes of neural cells in substantia gelatinosa of Rolando and cells in lateral horn (sympathetic neural centers) of spinal cord gray matter arose on the level corresponded to the displaced zygapophyseal joints. This is an evidence for the pain afferentation in FS of biomechanics nature.

Acknowledgement: I express my gratitude to histologists — N.F. Moroz, MD, ScD., and L.G. Goncharenko, MD, for assistance in preparation and assessment related to histological part of the investigation.

References


Фасетковий болючий синдром. Механізми гострої фази на прикладі грудного рухового сегмента хребта

В.В. Гонгальський

Резюме. На тварин (кірки) здійснювалося мінімальне фіксоване зміщення грудного хребця, що відтворювало biomechanічні зміни, виявлені на рентгенограмах у хворих на артралгію в ділянках грудних міжкребцьких суглобів (рентгенограв анатомія). Досліджено тканини залученого рухового сегменту хребта через 7 та 14 днів. Найвищу реактивність виявлено в ділянці вирусті синовіальної оболонки капсули міжкребцьких суглобів. Рисунки статевих білкових гіподермій і кісток з підкожними і гліколізованіми тонкими волокнами виріз синовії збільшувався більш ніж вдвічі внаслідок набряку і щільно вклинювався між робочими поверхніями суглоба (фасетками). Для порівняння на-

188
Фасеточный синдром. Механизмы острого фасеточного болевого синдрома

В.В. Гонгалъский

Резюме. На животных (кроликах) смоделирован минимально фиксированный сегментальный тип синовиальной субстанции, которое вызывало биомеханические изменения, приводящие к выявлению на рентгенограммах у больных с артралгией в области грудных межпозвоночных суставов (рентгенограмма призвена). Изучены ткани вовлеченных позаимствованных сегментальных суставов через 7 и 14 дней. Наиболее реактивным оказался сустав синовиальной оболочки патологического позаимствования. Обильное иннервирование нейрональными и слабомиелинированными тонкими нервыми волокнами вызвало синовиальную синергию, увеличивавшуюся в среднем более чем вдвое вследствие отека и плотно вклиневшись между суставными поверхностями (фасеткими). Для сравнения приведен неизмененный сустав синовиальной оболочки в сегментах, которые соответствовали диссектору.

Ключевые слова: фасеточный болевой синдром, межпозвоночные суставы, синовиальная оболочка, вырост синовиальной оболочки межпозвоночного сустава, диссектор, фасеточный спинальный реактивность.

Объем желудочков. В группе ресвератрола он увеличился в большей степени, чем в группе плацебо (33 и 27% соответственно), что должно было отразиться и на уровне когнитивного функционирования. Однако достоверных различий не было выявлено.

После курса лечения в группе ресвератрола некоторые показатели отличались от таких в группе плацебо, включая:

- Уровень Аβ40 в плазме крови и цереброспinalной жидкости (ЦСЖ) в среднем более чем вдвое (33% и 27% соответственно). Это вместе с изменениями в объеме мозга может служить основанием для дальнейших исследований на животных моделях (Metti A.L. et al., 2013). Учитывая то, что препарат не оказывал влияния на уровень тау-протеина в ЦСЖ и плазме крови, на объем гиппокампа или толщину эксторального коры, можно предполагать, что его можно использовать как натуральный препарат для лечения пациентов с болезнью Альцгеймера.

- Объем желудочков. В группе ресвератрола он увеличился в большей степени, чем в группе плацебо (33% и 27% соответственно). Это вместе с изменениями в объеме мозга может служить основанием для дальнейших исследований на животных моделях (Metti A.L. et al., 2013). Учитывая то, что препарат не оказывал влияния на уровень тау-протеина в ЦСЖ и плазме крови, на объем гиппокампа или толщину эксторального коры, можно предполагать, что его можно использовать как натуральный препарат для лечения пациентов с болезнью Альцгеймера.

- Уровень Аβ40 в плазме крови и ЦСЖ в среднем более чем вдвое (33% и 27% соответственно). Это вместе с изменениями в объеме мозга может служить основанием для дальнейших исследований на животных моделях (Metti A.L. et al., 2013). Учитывая то, что препарат не оказывал влияния на уровень тау-протеина в ЦСЖ и плазме крови, на объем гиппокампа или толщину эксторального коры, можно предполагать, что его можно использовать как натуральный препарат для лечения пациентов с болезнью Альцгеймера.

- Объем желудочков. В группе ресвератрола он увеличился в большей степени, чем в группе плацебо (33% и 27% соответственно). Это вместе с изменениями в объеме мозга может служить основанием для дальнейших исследований на животных моделях (Metti A.L. et al., 2013). Учитывая то, что препарат не оказывал влияния на уровень тау-протеина в ЦСЖ и плазме крови, на объем гиппокампа или толщину эксторального коры, можно предполагать, что его можно использовать как натуральный препарат для лечения пациентов с болезнью Альцгеймера.

- Объем желудочков. В группе ресвератрола он увеличился в большей степени, чем в группе плацебо (33% и 27% соответственно). Это вместе с изменениями в объеме мозга может служить основанием для дальнейших исследований на животных моделях (Metti A.L. et al., 2013). Учитывая то, что препарат не оказывал влияния на уровень тау-протеина в ЦСЖ и плазме крови, на объем гиппокампа или толщину эксторального коры, можно предполагать, что его можно использовать как натуральный препарат для лечения пациентов с болезнью Альцгеймера.

- Уровень Аβ40 в плазме крови и ЦСЖ в среднем более чем вдвое (33% и 27% соответственно). Это вместе с изменениями в объеме мозга может служить основанием для дальнейших исследований на животных моделях (Metti A.L. et al., 2013). Учитывая то, что препарат не оказывал влияния на уровень тау-протеина в ЦСЖ и плазме крови, на объем гиппокампа или толщину эксторального коры, можно предполагать, что его можно использовать как натуральный препарат для лечения пациентов с болезнью Альцгеймера.

Ключевые слова: фасеточный болевой синдром, межпозвоночные суставы, синовиальная оболочка, вырост синовиальной оболочки межпозвоночного сустава, диссектор, фасеточный спинальный реактивность.

Опубликовано в журнале "Ukr. Med. J., 10(6)–XI/XII 2014".