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Review article

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Balloon kyphoplasty for surgical treatment of aggressive vertebral hemangiomas (literature review)

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Abstract

Introduction Aggressive vertebral hemangiomas occur in 10–11.5 % of the working-age population that determines social significance of the disease. Percutaneous vertebroplasty technique is normally used for the treatment of aggressive spinal hemangiomas. Cement leakage is the most common complication during vertebroplasty (40–87. 5 %). Balloon kyphoplasty is associated with a low incidence of cement leakage. **Objective** We aimed to analyze literature and summarize information on balloon kyphoplasty used to treat aggressive spinal hemangiomas. **Material and methods** The original literature search was conducted on key resources including PubMed and GoogleScholar. Literature searches included both Russian and English studies based on keywords. **Results and discussion** The article presents the main results of balloon kyphoplasty used as a standalone procedure and in combination with other methods of surgical treatment of aggressive spinal hemangiomas. The use of balloon kyphoplasty was shown to reduce the risk of extraspinal cement leakage. However, this aspect is represented by a small number of scientific publications in the current medical literature that emphasizes the relevance of the topic raised. **Conclusion** Despite the variety of available treatment options, the optimal management strategy remains controversial for aggressive forms of vertebral hemangiomas. There are no well-defined criteria and indications reported recently to be included into a well-structured algorithm for of balloon kyphoplasty in the treatment of aggressive spinal hemangiomas, and therefore the debatable questions need further investigation.

Keywords: review, spine, aggressive hemangioma, complications, balloon kyphoplasty, vertebroplasty

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INTRODUCTION

Spinal hemangioma (SH) is encountered in 10 % of adults aged 30 to 60 years [1]. 90 % of all hemangiomas are malformations or telangiectasias resulting from adipose reduction of red bone marrow and 10 % of hemangiomas are vascular neoplasms [2]. Histologically, SH consists of many thin-walled vessels surrounded by fat and penetrating into the bone marrow cavity between the trabeculae [3]. Multiple SH are detected in 10–34 % of patients, and the frequency increases with age [4]. Hormonal disorders, pregnancy and injuries can accelerate the growth of hemangiomas [5, 6].

A local pain can be the only symptom of the disease in 55–90 % of cases [2]. Computed tomography (CT) and magnetic resonance imaging (MRI) are major modalities for diagnosis of SH [6, 7]. Clinically significant aggressive SH occur in 0.9–4 % of cases [8]. There are several criteria presented by different authors to include 6 to 10 signs of aggressive hemangiomas to establish the diagnosis of "aggressive hemangioma" [2]. The well-known criteria in English literature are those proposed by Laredo J. et al. (1986) [9] and Deramond N. et al. (2002) [10]. Kravtsov M. N. et al. (2012) offered a scale for assessing the aggressiveness of spinal hemangiomas that includes 9 radiological and clinical criteria with a score from 1 to 5 to establish the aggressiveness of a hemangioma [11]. Aggressive SH are accompanied by intracanal growth in 1 % of cases with resultant spinal canal stenosis and narrowing of intervertebral foramen and a gradual increase in neurological symptoms (radicular syndrome, paraesthesia, conductive sensory disorders, paresis and paralysis) [2, 12, 13]. As the hemangioma grows, gradual restructuring of the bone tissue of the vertebral body occurs and can lead to its pathological fracture [14, 15, 16].

Percutaneous vertebroplasty (PV) is normally used for the treatment of aggressive spinal hemangiomas [17] aimed at restoring the supporting capacity of the affected vertebra and achieve analgesic effect [18]. Complications of PV occur in 0.5 to 76 % of cases [19] with 2.5 % being clinically significant [20]. The most common (40–87.5 % of cases) complications are associated with the migration of polymethylmethacrylate outside the vertebral body [21, 22] and can lead to neurological disorders [23]. Lotfinia I. et al. (2010) reviewed the results of PV and reported migration of polymethylmethacrylate into intervertebral discs in 23.3 % of cases, foraminal and epidural migration of the polymer in 20 % of the patients, and extravertebral spread through segmental vessels in 6.7 % of other complications [24]. Klimov V.S. et al. (2018) described the results of surgical treatment of aggressive SH using PV and reported complications caused by the migration

of bone cement outside the vertebral body [23]. Migration of bone cement into the intervertebral disc can lead to a compression fracture of the body of the adjacent vertebra in osteoporotic patients [25, 26]. In order to reduce the risk of polymethylmethacrylate migration, various methods of augmentation of the affected vertebra are used. Staged introduction and use of more viscous polymer, positioning of the needle with maximum convergence to the anterior parts of the body of the affected vertebra, as well as the introduction of bone cement under minimal pressure can be employed [27, 28]. The risk of extravertebral bone cement leakage remains high and ranges from 2 to 11 % of cases [21].

Balloon kyphoplasty (BK) is also applied for the treatment of SH [29]. The technique of vertebroplasty was developed in 1998 for the treatment of compression vertebral fractures in osteoporotic patients [30]. The main difference between BK and PV is the preliminary introduction of a special balloon into the body of the injured vertebra using a puncture needle [31]. BK helps to restore the height of the body of the affected vertebra by forced spreading of the balloon and reduces the risk of extravertebral leakage of the bone composite due to compaction of bone tissue along the periphery [32]. Despite the available publications on the use of the BK technique in the treatment of aggressive SH [29, 33–35], we were unable to find a large-scale clinical study on its use in a large cohort of patients. Most are case reports and there is a paucity of reports in Russian literature decsribing surgical treatment of aggressive SH [36–38].

Objective We aimed to analyze literature and summarize information on balloon kyphoplasty used to treat aggressive spinal hemangiomas.

MATERIAL AND METHODS

The original literature search was conducted on key resources including PubMed and GoogleScholar. Literature searches included both Russian and English studies based on keywords «spinal hemangioma», «percutaneous vertebroplasty», «complications», «balloon kyphoplasty». Earlier publications were added to reveal important aspects of the issue, if needed.

RESULTS

The use of BK in the treatment of aggressive SH was first described by Noez S. et al. (2006) [39] and Atalay B. et al. (2006) [40]. Hadjipavlou A. et al. (2007) retrospectively reported 6 patients who underwent a total of 8 surgical interventions on the thoracic and lumbar spine [29]. The average follow-up period was 22.3 months. Severe pain was the indication for surgical intervention. CT scans showed all vertebral bodies totally involved and cortical defects in some cases. The benefit of BK was reduced risk of extravertebral leakage of the bone composite through cortical defects. One of the patients who underwent right-sided BK developed pain after six months caused by the growth of hemangioma in the left half of the body of the operated vertebra. The authors produced complete hemangioma augmentation with polymethylmethacrylate using a two-portal BK [29].

The use of BK for hemangioma in the cervical spine was first described by Zapalowicz K. et al. (2008), who reported a positive result of the treatment of vertebral hemangioma C7 in a 49-year-old patient [33]. CT examination showed thinning of the posterior cortical wall of the body of the C7 vertebra that was a contraindication for the use of PV to avoid leakage of the composite into the spinal canal. The authors performed BK using anterolateral access. Postoperative CT examination confirmed the absence of extravertebral migration of polymethylmethacrylate, and examination at 6 and 12 months showed the absence of recurrent hemangioma growth. According to the authors, high-viscosity acrylic cement introduced under low pressure into the cavity formed by a forcibly straightened balloon reduces the risk of extravertebral cement extrusion due to the fact that the composite follows the path of least resistance into the "alternative" cavity [33].

Jones J.O. et al. (2009) reported two cases of successful treatment of aggressive SH using BK [41]. The first case was a 38-year-old man with persistent pain syndrome (8/10 on the VAS scale) in presence of aggressive hemangioma of the L5 vertebra that occupied up to 60 % of his body. The patient underwent bilateral BK under local anesthesia. There were no complications in the postoperative period. The second case was a 75-year-old patient suffering from a severe pain syndrome (10/10 on the VAS scale). A pathological fracture of the body of the Th12 vertebra was diagnosed due to aggressive hemangioma. The patient underwent BK. Intraoperative leakage of the composite outside the vertebral body was not observed. Subsequently, a complete regression of the pain syndrome was noted. Based on the results of the patients, the authors concluded that BK can reduce the risk of extravertebral migration of bone cement compared to PV due to the formation of an "alternative" internal cavity in the body of the affected vertebra, thereby confirming the findings reported by Hadjipavlou A. et al. (2007) and Zapalowicz K. et al. (2008). They also concluded that BK can be

used for the treatment of aggressive SH complicated by a pathological fracture of the body to restore its height and supportability and to avoid transpedicular fixation [41].

Moore J.M. et al. (2012) presented 2 cases of successful use of BK in combination with transpedicular fixation in the treatment of complicated aggressive SH [34]. An unstable pathological fracture of the body of the Th12 vertebra was detected due to hemangioma in one case, and progressive compression of the spinal cord by the soft tissue component of the tumor at the level of the Th6 vertebra with the presence of neurological deficiency observed in the other patient. A spinal angiogram with embolization of the blood vessels feeding the hemangioma and laminectomy were performed in the second case. In both cases, there were no complications in the postoperative period. The authors reported that BK could stabilize the vertebral body and have an additional effect on the tumor when the cement "solidifies" by generating an exothermic reaction that was also observed when using PV. The combination of BK and transpedicular fixation reduced the risk of postlamynectomy kyphosis, and therefore the authors recommended using BC when the posterior elements of the vertebra were destabilized after decompressive laminectomy [34].

The findings can be confirmed by report of Armaganian G. et al. (2013) who presented the result of treatment of a pathological fracture of the body of the L1 vertebra due to hemangioma injury as a result of high-energy trauma in a 39-year-old patient [14]. CT scan showed an unstable explosive fracture of the body. The patient underwent transpedicular fixation and BK of the vertebral body from bilateral transpedicular access with preliminary embolization of the vascular bed of the tumor to prevent pathological segmental kyphosis at the injury level and restore the vertebral body supportability. The treatment could facilitate regression of the pain and more rapid activation of the patient. The authors emphasized that the volume of injected polymethylmethacrylate should not exceed the volume of inflated balloons to reduce the risk of extravertebral migration of bone cement with cortical layer defects [14].

Syrimpeis V. et al. (2014) reported effective treatment of complicated SH in a 73-year-old patient who was diagnosed with total aggressive hemangioma of the L3 vertebral body and a soft tissue epidural component [42]. The patient underwent right-sided hemilaminectomy with decompression of the nerve root, BK and segmental stabilization at the L2–L4 level. The postoperative period was uneventful. The authors suggested that the combination of posterior decompression, vertebral augmentation with BK and subsequent posterior fixation in patients with neurological deficiency minimized development of symptoms and allowed for early rehabilitation [42]. The use of combined surgical treatment of complicated aggressive SH was also described by Yu B. et al. (2014) [43].

Sedeno B. et al. first (2017) reported a clinical case of a combined treatment of a complicated aggressive hemangioma of the Th5 vertebral body detected in a 56-year-old patient using intraoperative radiation therapy in combination with BK [44]. The patient had intense pain syndrome, gait instability and decreased sensitivity in the lower extremities. CT revealed a total lesion of the body of the Th5 vertebra with an aggressive hemangioma complicated by intraspinal growth (narrowing of the lumen of the spinal canal by a soft tissue component up to 50 %). Intraoperative radiation therapy with an irradiation dose of 30 Gy was performed followed by BK. There were no intraoperative complications, and complete regression of the pain syndrome was noted a day after surgery. Postoperative CT and MRI scans showed decreased volume of the epidural soft tissue component and revealed no cement associated complications. The authors suggested that BK in combination with intraoperative radiation therapy can be considered a new method of treatment of complicated aggressive GP using single-fraction radiation therapy performed in combination with BK. The combined approach can be a good alternative to the treatment of the patients to avoid the use of more aggressive surgical techniques, such as laminectomy and subsequent transpedicular stabilization [44].

Giorge P. et al. (2020) offered an original technique for BK with simultaneous preoperative embolization of the pathological vascular bed of the tumor [35]. The authors presented a case of total aggressive hemangioma of the body of the L5 vertebra in a 58-year-old man with intense pain. CT and MRI examination revealed extensive osteolytic lesion of the body and the left pedicle of the L5 vertebra with an intrusion into the spinal canal. The patient underwent selective embolization (polyvinyl alcohol particles were injected into the common trunk of the artery feeding the tumor) combined with transpedicular biportal BK. The authors offered the so-called "eggshell" technique to minimize the risk of cement leakage through defects in the posterior cortical wall of the vertebral body. A small amount of polymethylmethacrylate was first injected into the vertebral body, and then balloons were slowly inflated to press the cement against the walls of the cavity in order to augment cortical defects. When the "cement shell" solidified, the balloons were removed, and the remaining bone composite was injected according to the standard procedure used in vertebroplasty. No intraoperative complications were detected. Postoperative CT

scans showed total filling of the osteolytic defect of the L5 vertebra. A follow-up at 5 years showed no radiological or clinical signs of recurrence. The authors concluded that embolization with a subsequent stage-by-stage augmentation of the vertebra can be considered a safe and effective minimally invasive procedure, in the presence of a cortical defect of the body of the affected vertebra, in particular [35].

DISCUSSION

PV is the most common method of treating aggressive SH and can be associated with postoperative complications [23]. Polymethylmethacrylate leakage is a very frequent occurrence in vertebroplasty [24]. BK can be useful for aggressive SH that is associated with a cortical defect of the body of the affected vertebra taking into account potential complications [35]. BK reduces the risk of polymethylmethacrylate leakage due to the fact that the composite follows the path of least resistance into an already formed "alternative" cavity in the body of the affected vertebra [33]. With the same pathology at baseline, BK appeared to be more effective in the treatment of aggressive SH in comparison with PV in terms of pain relief and restoration of vertebral supportability avoiding polymethylmethacrylate leakage. In our opinion, in addition to benefits of BK in the treatment of SH, the technique has some limitations during surgery depending on the level of kyphoplasty and the anatomy of the vertebrae. BK can be more effective for hemangiomas of the lower thoracic and lumbar spine with the need to create a large diameter pin channel (5–6 mm) in the pedicles to place the balloon. The "thin" pedicles of the affected vertebra make the manipulation difficult to perform and can result in a fracture. In such cases, preference should be given to PV using cement of higher viscosity and with sufficient "working" time to reduce the risk of extravertebral migration.

CONCLUSION

Literature analysis showed that BK can be the method of choice in the surgical treatment of hemangiomas with a high risk of bone cement migration [33, 35, 41]. BK can be effectively used in combination with other methods of treatment of aggressive SH [14, 34, 43, 44]. There are no well-defined criteria and indications reported recently to be included into a well-structured algorithm for of balloon kyphoplasty in the treatment of aggressive spinal hemangiomas, and therefore the debatable questions need further investigation.

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