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REVIEW ARTICLE

Management of pulmonary cement embolism after percutaneous vertebroplasty and kyphoplasty: a systematic review of the literature

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Abstract Balloon kyphoplasty and percutaneous vertebroplasty are relatively recent procedures in the treatment of painful vertebral fractures. There are, however, still some uncertainties about the incidence and treatment strategies of pulmonary cement embolisms (PCE). In order to work out a treatment strategy for the management of this complication, we performed a review of the literature. The results show that there is no clear diagnostic or treatment standard for PCE. The literature research revealed that the risk of a pulmonary embolism ranges from 3.5 to 23% for osteoporotic fractures. In cases of asymptomatic patients with peripheral PCE we recommend no treatment besides clinical follow-up; in cases of symptomatic or central embolisms, however, we recommend to proceed according to the guidelines regarding the treatment of thrombotic pulmonary embolisms, which includes initial heparinization and a following 6-month coumarin therapy. In order to avoid any types of embolisms, both procedures should only be performed by experienced surgeons after critical determination of the indications.

Keywords Vertebroplasty · Kyphoplasty · Complication · Cement leakage · Pulmonary embolism

Introduction

Percutaneous vertebroplasty (PVP) and Balloon kyphoplasty (BKP) are recently introduced procedures in the treatment of painful vertebral fractures, especially those caused by osteoporosis. The large number of internationally published case reports and clinical studies shows that since the initial performance of the percutaneous vertebroplasty by Galibert et al. [24] as well as of the percutaneous kyphoplasty through Reiley et al. [26] both procedures are being extensively used throughout the world.

So far, numerous studies have shown the medical benefits especially regarding pain relief of those two types of interventions in different medical conditions [2, 20]. Originally the percutaneous procedure was designed to treat painful vertebral destructions caused by hemangiomas [24]. Today there are numerous other indications for percutaneous vertebroplasty and kyphoplasty, e.g. osteoporotic vertebral fractures [5] as well as vertebral fractures caused by tumors [28, 56, 94] and burst fractures [19, 63, 84].

Despite, or maybe because of, the wide usage of those two surgical techniques, reports of complications are increasing. These complications are very complex and range from refractures of already stabilized vertebrae [52, 53, 86] to fractures of neighboring vertebrae [10, 67], persisting pain [27] and several types of injuries caused by the access up to cement leakage.

Cement leakage is the most frequent complication arising after percutaneous vertebroplasty and kyphoplasty [4, 59, 68]. The leakages range from asymptomatic damages of the surrounding tissue to nerve irritation through compression of nerve roots [40, 45, 75] and pulmonary cement embolisms (PCE) [3, 18, 21, 42].

It is assumed that in many cases, many embolisms remain undetected. Due to the exposure to radiation, X-rays of the lungs are not always performed after BKP or PVP. This also explains why there are no clear treatment strategies after the occurrence of pulmonary cement embolisms.

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We therefore performed a review in order to elaborate a treatment recommendation for the management of such complications, derived from field reports as stated in the respective reports in the literature.

Methodology

As part of a literature research, we analyzed international data bases [e.g. PubMed, Medline, Cochrane Library, Food and Drug Administration (http://www.accessdata.fda.gov/scripts/cdrh/cfdocs/cfMAUDE/Search.cfm)]. We also took into consideration recommendations from national and international guidelines and professional associations (Arbeitsgesellschaft der wissenschaftlichen medizinischen Fachgesellschaften (AWMF), SIGN, American College of Radiology; Deutsche Röntgengesellschaft) as well as a hand-selected literature from references of important publications dealing with this topic.

All case reports and clinical series published on vertebroplasty and kyphoplasty were searched. In order to make a statement about the incidence and about the treatment of pulmonary cement embolisms after percutaneous vertebroplasty and kyphoplasty, the literature found was searched for information regarding such complications. All publications were searched for pulmonary cement embolisations. Indications and therapies were analyzed. There were no exclusion criteria for the literature found except literature other than published in English, german or French.

Results

The literature analysis showed that up to October 2008, there were 1,222 entries with the keywords "Vertebroplasty or Kyphoplasty" in Pubmed. Amongst them were 214 case reports. Ninety-five cases reported of complications after vertebroplasty or kyphoplasty. In those 95 cases, 90 were observed after PVP and 5 after BKP, respectively. Thirty-four of those 95 listed cases reported cases of pulmonary cement embolism. All embolisms occurred after a percutaenous vertebroplasty.

There were 12 reports about patients, in which, during a postoperative routine examination, i.e. either conventional X-rays or computed tomography of the thoracic organs, an asymptomatic pulmonary embolism caused by venous PMMA leakage was detected (Table 1).

Twenty-four authors report 27 patients, of which 25 patients have suffered a symptomatic pulmonary cement embolism. The most common symptom was dyspnea. Although in a great amount of cases the symptoms described only lasted for a short period of time, four of the case reports stated that a percutaneous vertebroplasty resulted in the patients death [16, 57, 85, 95] (Table 2).

Table 1 Case reports about patients with asymptomatic pulmonary embolisms

Authors	Number of patients	Number of asymptomatic PCE	Procedure and Indication	Therapy
Abdul-Jalil [1]	2	1	PVP, osteoporotic fracture	Low dose heparin
Baumann [8]	1	1	PVP, osteoporotic fracture	Coumarin for 3 months
Bernhard [9]	1	1	PVP, osteoporotic fracture	–
Bonardel [12]	1	1	PVP, osteoporotic fracture	Coumarin for 6 months
Freitag [23]	1	1	PVP, osteoporotic fracture	Coumarin for 6 months
Jang [38]	3	1	PVP, myeloma	Low dose heparin
Mac Taggert [54]	1	1	PVP, osteoporotic fracture	–
Neuwirth [60]	1	1	PVP, osteoporotic fracture	–
Pleser [71]	1	1	PVP, osteoporotic fracture	Heparin + coumarin for 6 months
Quesada [74]	1	1	PVP, osteoporotic fracture	–
Schneider [78]	1	1	PVP, osteoporotic fracture	–
Seo [81]	1	1	PVP, osteoporotic fracture	Operative embolectomie

Table 2 Case reports about patients with symptomatic pulmonary embolisms

Authors	Number of patients	Number of symptomatic PCE	Procedure and indication	Therapy
Abdul-Jalil [1]	2	1	PVP, osteoporotic fracture	Low dose heparin
Charvet [15]	1	1	PVP, osteoporotic fracture	–
Chen [16]	1	1	PVP, osteoporotic fracture	CPR
Francois [22]	1	1	PVP, osteoporotic fracture	Coumarin 6 months
Harris [30]	1	1	PVP, osteoporotic fracture	–
Jang [38]	3	2	PVP, osteoporotic fracture	Anticoagulation with heparin
Kim [41]	1	1	PVP, osteoporotic fracture	Operative embolectomy
Leroux [48]	1	1	PVP, osteoporotic fracture	–
Liliang [49]	1	1	PVP, osteoporotic fracture	No anticoagulation
Lim [50]	1	1	PVP, osteoporotic fracture	Operative embolectomy
Lim [51]	1	1	PVP, osteoporotic fracture	Operative embolectomy
Monticelli [57]	1	1	PVP, osteoporotic fracture	CPR
Padovani [65]	1	1	PVP, histiocytosis	Anticoagulation
Perrin [66]	1	1	PVP, osteoporotic fracture	Low dose heparin
Pott [72]	1	1	PVP, osteoporotic fracture	Low dose heparin
Righini [76]	1	1	PVP, osteoporotic fracture	Coumarin 6 months
Schoenes [79]	1	1	PVP, osteoporotic fracture	Operative embolectomy
Scroop [80]	1	1	PVP, osteoporotic fracture	No Anticoagulation
Son [83]	1	1	PVP, osteoporotic fracture	Operative embolectomy
Stricker [85]	1	1	PVP, osteoporotic fracture	Definitive airway
Torres Machi [88]	1	1	PVP, osteoporotic fracture	Anticoagulation
Tozzi [89]	1	1	PVP, osteogenesis imperfecta	Coumarin 3 months
Yoo [95]	1	1	PVP, osteoporotic fracture	Operative embolectomy
Zaccheo [96]	1	1	PVP, osteoporotic fracture	Low dose heparin

Table 3 Case series reporting about patients with symptomatic pulmonary embolisms

Authors	Number of patients	Number of symptomatic PCE	Procedure and indication	Therapy
Amar [2]	97	1	PVP, indication unclear	–
Barragan-Campos [7]	117	1	PVP, spinal metastasis	Oral anticoagulation
Calmels [13]	52	2	PVP, spinal metastasis	Oral anticoagulation
Caudana [14]	106	2	PVP, indication unclear	–
Chen [17]	70	1	PVP, osteoporotic fracture	–
Duran [21]	73	4	PVP, indication unclear	Low dose heparin
Heffernan [32]	?	2	PVP, indication unclear	–
Jang [37]	28	2	PVP, osteolytic Spinal metastasis	Anticoagulation
Layton [46]	552	1	PVP, indication unclear	–
Pitton [70]	251	1	PVP, indication unclear	–
Wong [93]	85	1	BKP, osteoporotic fractures	–

Until October 2008, 387 clinical studies regarding "kyphoplasty or vertebroplasty" were identified. There were only two prospective randomized studies. One of these studies compared the short time effects of vertebroplasty with conservative treatment. The other study evaluated the relative risk of adjacent fractures after BKP. Both studies did not report PCE. All other studies were case series Level IV according to the Oxford criteria of evidence based medicine.

The analysis of all case series showed 86 cases of pulmonary cement embolisms in about 20,000 patients (Tables 3, 4, 5) (Fig. 1). In the majority of the publications the indications for Vertebroplasty are osteoporotic fractures refractory to conservative treatment and painful

Table 4 Case series reporting about patients with asymptomatic pulmonary embolisms

Authors	Number of patients	Number of asymptomatic PCE	Procedure and indication	Therapy
Amar [2]	97	2	PVP, indication unclear	–
Anselmetti [3]	49	2	PVP, indication unclear	–
Barbero [5]	101	4	PVP, indication unclear	–
Barragan-Campos [7]	117	1	PVP, spinal metastasis	No anticoagulation
Choe [18]	64	4	PVP, spinal metastasis	No anticoagulation
Duran [21]	73	1	PVP, indication unclear	Low dose heparin
Gangi [25]	868	2	PVP, indication unclear	–
Grados [29]	40	1	PVP, osteoporotic fracture	–
Hauck [31]	269	1	PVP, indication unclear	–
Hierholzer [33]	18	1	PVP, indication unclear	–
Hierholzer [34]	75	1	PVP, indication unclear	–
Hodler [36]	152	10	PVP, indication unclear	–
Jang [37]	28	1	PVP, osteolytic spine tumor	Anticoagulation
Kaufmann [39]	158	4	PVP, indication unclear	–
Koyama [44]	17	1	PVP, indication unclear	–
Legroux-Gerot [47]	31	1	PVP, osteoporotic fracture	–
Masala [55]	624	2	PVP, indication unclear	–
Moreland [58]	35	2	PVP, indication unclear	No anticoagulation
Ormsby [64]	54	1	PVP, indication unclear	–
Pitton [70]	251	3	PVP, indication unclear	–
Purkayashta [73]	46	1	PVP, indication unclear	–
Serra [82]	175	3	PVP, osteoporotic fracture	–
Tanigawa [87]	76	1	PVP, osteoporotic fracture	–
Venmans [91]	299	11	PVP, osteoporotic fracture	–
Walz [92]	57	1	PVP, osteoporotic fracture	No anticoagulation

Table 5 Case series reporting about pulmonary embolisms, without further going into detail to what extent they were symptomatic or asymptomatic

Authors	Number of patients	Number of PCE	Procedure and indication	Therapy
Koch [43]	68	1	PVP secondary osteoporosis	–
Nöldge [61]	40	2	PVP, osteoporotic fracture	–
Pitton [69]	191	2	PVP, osteoporotic fracture	–
Trout [90]	69	1	PVP, osteoporotic fracture	–

metastasis of the spine. Most of the studies report about case series with patients that had undergone surgery for different indications. When indications are mixed most authors do not specify when PCE has occurred.

Eleven authors describe 18 symptomatic pulmonary embolisms in 1,430 patients after percutaneous vertebroplasty or kyphoplasty (Table 3). One author describes a patient's death on the eighth day after a percutaneous vertebroplasty that was caused by a symptomatic cement embolism [7]. After surgery the patient had been given anticoagulants oraly.

Twenty-five authors describe asymptomatic cement embolism after such procedures. According to them there were 62 cases of asymptomatic pulmonary cement embolisms that occurred during the treatment of 3,774 patients (Table 4).

Four other clinical studies cover the treatment of 368 patients with 6 pulmonary cement embolisms, without going into further detail to what extent they were symptomatic or asymptomatic (Table 5).

In the publications listed above, the pulmonary cement embolisms were solely recognized through its clinical

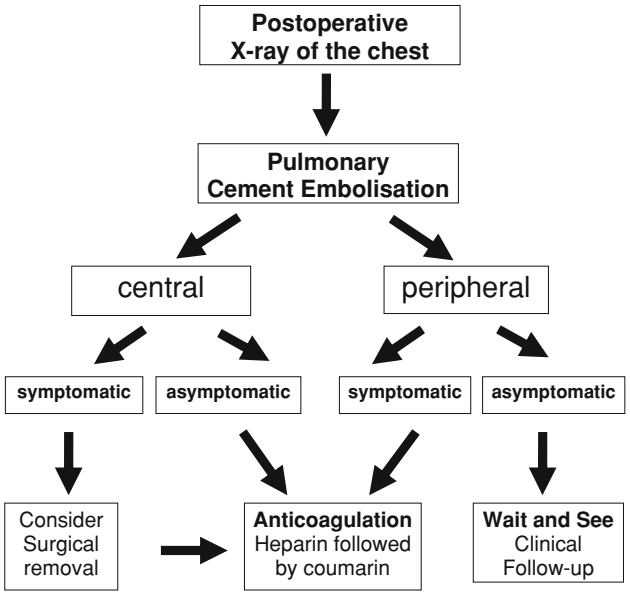

Fig. 1 Decision tree for the management of pulmonary cement embolism as applied in our institution

symptoms or due to incidentally performed X-rays of the thoracic organs.

Only four studies, i.e. the case series by Choe et al. [18], Anselmetti et al. [3], Duran et al. [21]. and Kim [42], explicitly examined the risk of developing pulmonary embolisms in their own patients through standardized postoperative radiography (CT and/or conventional radiography) of the thoracic organs. The risk ranges from 3.5 to 23%.

While most of the authors recommend anticoagulation after having experienced pulmonary cement embolism, there were actually five cases which required open cardiac surgery in order to remove the cement from the lungs and from the right perforated ventricle.

Two hundred thirty-nine clinical complications resulting from vertebroplasty and kyphoplasty were reported to the FDA. Fourteen of those 239 cases were actual pulmonary cement embolisms (3 after PVP, 11 after BKP).

Six reported complications describe asymptomatic pulmonary embolisms through PMMA leakage after vertebroplasty and kyphoplasty that were detected in postoperative routinely taken X-rays in asymptomatic patients.

There were eight cases of symptomatic cement embolisms that ranged from light dyspnea with follow-ups that did not require further treatments to cement removal at the heart and lungs during open cardiac surgery. The FDA has not received any notices about any cases of death caused by cement embolisms.

Discussion

Transvertebral cement leakages into surrounding tissues as well as leakages into paravertebral veins are common complications after percutaneous vertebroplasty and kyphoplasty [36]. In studies that performed computed tomography of the treated vertebral bodies after PVP or BKP the percentage reaches up to 90% in PVP [77] and up to 37.5% [31] in BKP. The leakages are mostly caused by the injection of polymethylmethacrylate (PMMA) that is still too liquid or by applying too much pressure while injecting the material.

In the majority of those cases, cement leakage does not cause any problems and is usually detected during a radiographic control. Those types of cement leakages seem to be harmless complications after percutaneous vertebroplasty and kyphoplasty and require no further therapy [14]. Nevertheless, pulmonary cement embolisation leading to death can be the aftereffect of uncontrolled leakage. Most of the reports of PCE are case reports and have been observed after PVP. Amongst the reported complications to the FDA there are also PCE after BKP [62].

Based on clinical appearance there are two main groups of lung embolisms, asymptomatic and a symptomatic cement embolism. Symptomatic cement embolisms can be recognized by their clinical signs and symptoms such as dyspnea/tachypnea, tachycardia, cyanosis, chest pain, coughing, hemoptysis, dizziness and sweating [9, 38, 65, 89] whereas it is more difficult to recognize asymptomatic cement embolisms.

So far, only four studies have studied the risks of pulmonary embolisms caused by PVP and BKP in their patients [3, 18, 21, 42]. In these studies X-rays [3] or computed tomography [42] of the lungs were consequent performed in all patients. The risk for cement embolism ranges between 3.5 and 23% based on the type of imaging. Therefore, the incidence of pulmonary cement extravasation may be underestimated and has a high clinical relevance.

While in the case of Choe et al. [18], only patients with malignomas of the vertebras were treated, Anselmetti et al. [3] as well as Duran et al. [21] mainly treated patients with compression fractures caused by osteoporosis. Duran found four PCE after vertebroplasty in osteoporotic fractures and one after treating a fracture caused by Myeloma. The highest percentage of 23% of PCE was found after vertebroplasty in osteoporotic fractures [42]. In this case, series computed tomography of the chest was performed in all cases. Based on the available literature it is not possible to draw the conclusion that malignomas have a higher risk for PCE.

Some authors recommend a standardized radiographic control of the thoracic organs within the first 24 h after

surgery. The risk of 3.5–23% for pulmonary embolisms justifies to our understanding the need of postoperative X-rays of the lungs even in asymptomatic patients. It has to be questioned if a CT scan that has a higher sensitivity for the detection of pulmonary embolisms is justified for screening. Venmanns et al. [91] propose a computed tomography when the embolisation was visualized during the operative procedure. This study group recognized 11 PCE in there study group (2.1%) but did not perform imaging in all patients.

Even after review of the literature, it is not possible to derive a clear treatment strategy for the treatment of pulmonary cement embolisms. The quality of the studies do not allow a satisfactory statistical analysis. The evidence level of the studies does not exceed grade IV. Besides surgical removal, treatment options include administration of heparin i.v. or s.c., observation of the clinical spontaneous progress or coumarin treatment for 3–6 months after the occurrence of the embolism.

A few authors [71, 89] suggest surgical removal of the thrombus in cases of symptomatic patients with central embolisms, since medicinal reopening of the occludes vessels seems to be impossible. Other authors [95] regret surgical embolectomy that resulted in the patient's death after a pulmonary cement embolism.

In the field of new technologies there does not exist evidence based data to underlay treatment guidelines. Taking all literature in account we recommend no treatment in asymptomatic patients with peripheral embolisms (Fig. 1). These patients should be clinically reevaluated. In cases of symptomatic peripheral embolisms or central embolisms we recommend a treatment in accordance to the guidelines of the Seventh ACCP Conference on Antithrombotic and Thrombolytic Therapy [35] and guidelines of the german society of phlebologists for the treatment of thrombotic pulmonary embolisms with initial i.v. heparinization and then 6 months of consecutive coumarin therapy. Surgical embolectomy should only be performed in exceptional cases of central embolisms.

The thrombogenic cement can additionaly lead to progressive occlusion of pulmonary arteries. After 6 month of therapy with coumarin to avoid additional thrombosis, the foreign object is endothelialized [76] which seemingly bans the danger of a progression of the occlusion.

A continuous anticoagulation therapy after the initial 6 months of treatment does not seem to be indicated and due to the associated bleeding complications in the prevalent older population it is actually contraindicated.

In order to give a general recommendation for avoiding cement embolisms, we have to note that the bone cement used should have a viscous, toothpaste-like consistency. There is hard evidence on experimental work that viscosity of the bone cement is one crucial parameter regarding the risk for leakage [6, 11]. The Injection should be stopped as soon as one of the personnel present realizes that there is paravertebral or even intravenous cement extravasation. Medicinal personnel should be especially careful in the case of vertebras already damaged by malignomas [18], since firstly it is possible that the cortical substance is already damaged and secondly that in those cases there is often an increased vascularization of the vertebras [20]. The quantity of cement leakage is also dependent of the total cement volume used in both procedures. The clinical outcome concerning pain control seem to be independent from the cement volume used [39].

Both procedures should only be performed by experienced surgeons or interventionalists after critical indication under fluoroscopic or computer-tomographic monitoring.

The risk for PCE seems to be higher in vertebroplasty than in kyphoplasty. Up to date there are no randomized trials comparing both procedures. The study design for upcoming studies should take this complication in account.

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