BMJ Open

# Knowledge, attitudes and practices regarding spinal vascular malformations among doctors in China: a cross-sectional study

Zhongjun Yan,[1] Lingling Fan,[2] Dongwei Xu,[3] Jie Ma,[1] Yan Hu,[1] Jiang Li,[1] Yufeng Liu [1]

**To cite:** Yan Z, Fan L, Xu D, *et al*. Knowledge, attitudes and practices regarding spinal vascular malformations among doctors in China: a cross-sectional study. *BMJ Open* 2024;**14**:e077698. doi:10.1136/bmjopen-2023-077698

► Prepublication history and additional supplemental material for this paper are available online. To view these files, please visit the journal online (https://doi.org/10.1136/bmjopen-2023-077698).

ZY, LF and DX contributed equally.

Received 12 July 2023
Accepted 28 January 2024



[1]Department of Neurosurgery, Air Force Medical University Tangdu Hospital, Xi'an, Shaanxi, China
[2]Department of Neurology, Xi'an First Hospital Affiliated to Xi'an Medical University, Xi'an, Shaanxi, China
[3]Department of Neurosurgery, 78th Group Army Hospital of Chinese PLA, Mudanjiang, Heilongjiang, China

**Correspondence to**
Dr Yufeng Liu;
lyfnokia6303@163.com

## ABSTRACT

**Objective** Knowledge, attitude and practice (KAP) models are essential tools for assessing healthcare professionals' understanding, beliefs and behaviours towards specific health issues. This study aimed to explore the KAP of Chinese doctors in diagnosing and treating spinal vascular malformations (SVM).

**Design** A web-based cross-sectional survey.

**Setting** This study was conducted between October and December 2022 through a self-administered questionnaire.

**Participants** Participants include full-time doctors who voluntarily participate. Doctors in advanced training, regular training or internships were excluded.

**Primary and secondary outcome measures** The KAP scores of Chinese doctors in diagnosing and treating SVM measured by the questionnaire.

**Results** A total of 517 doctors participated in the study, mostly in Shaanxi, China, working in SVM-relevant departments (n=396) or other departments (n=121). The doctors achieved an average knowledge score of 9.66±1.95 (range: 0–12), attitude score of 22.16±1.71 (range: 6–30) and practice scores of 46.13±5.35 for those in SVM-relevant departments (neurosurgery, orthopaedics and neurology) and 8.50±1.25 for those in other departments, respectively, revealing doctors have adequate knowledge, positive attitude and good practice, and those in SVM-relevant departments showing more adeptness compared with those in other departments. Moreover, multivariate logistic regression analysis showed that knowledge about SVM (OR=1.72, 95% CI 1.11 to 2.65, p=0.015), holding a master's degree (OR=1.85, 95% CI 1.14 to 3.00, p=0.013) and working in orthopaedics (OR=0.34, 95% CI 0.13 to 0.88, p=0.026) were independently associated with good attitude.

**Conclusion** Chinese doctors showed adequate knowledge, moderate attitudes and good practice regarding SVM. A continuing education programme may improve clinical practitioners' ability to manage SVM.

## STRENGTHS AND LIMITATIONS OF THIS STUDY

⇒ The questionnaire was developed based on expert consensus and revised through input from multiple experts, enhancing the content validity of the instrument.
⇒ The study included doctors from both spinal vascular malformations (SVM)-relevant departments and other departments, providing insights into the variations in knowledge, attitude and practice across different specialties.
⇒ The study relied on self-reported data, which may be subject to recall bias or social desirability bias, potentially impacting the accuracy of responses.
⇒ The study focused on Chinese doctors, specifically those in Shaanxi, which restricts the generalisability of the findings to a broader population or different geographical regions.
⇒ The study, being cross-institutional within China, overlooks the influence of varied cultural norms, socioeconomic status, political and legal frameworks, educational and health systems, and technological access, which limits its generalisability to different international contexts.

## INTRODUCTION

Spinal vascular malformations (SVM) are rare and complex clinical entities that may cause progressive spinal cord symptoms and irreversible disability in the absence of timely and proper treatment.[1 2] Several classification systems have been developed for SVM, but the most widely used is based on the site (dural, intradural and extradural) and type (arteriovenous fistulas and arteriovenous malformations) of arteriovenous shunts.[1 3] The most common type of SVM is spinal dural arteriovenous fistula (SDAVF), which accounts for 60%–80% of all cases.[4] Endovascular and surgical treatments are available for SVM depending on the type and location of the lesion.[5] Angiography is the gold standard for diagnosis, and MRI and magnetic resonance angiography (MRA) are increasingly being used for screening.[4] However, due to the vague and slow-developing symptoms, many patients go undiagnosed or misdiagnosed.[6]

In a recent study, 35% of patients with SDAVF had a documented misdiagnosis, with

a significantly longer symptom duration before treatment (2.3 vs 0.9 years) and worse clinical outcomes than patients without a misdiagnosis.[7] According to an earlier study, patients with SDAVF underwent extensive and unsuccessful workups and even unnecessary surgeries due to misdiagnosis for up to 36 months before being diagnosed.[8] The early diagnosis and treatment of SVM may significantly improve outcomes and even prevent permanent disability and death.[1] Increasing clinician awareness of this rare condition is crucial to making an accurate diagnosis.

Knowledge, attitude and practice (KAP) surveys are commonly used in the health sciences to examine what people know, believe and do about a topic of interest.[9]

To the best of our knowledge, no prior KAP surveys have been reported on SVM among healthcare professionals. This study stands as the pioneering effort to assess the KAP of Chinese doctors from various specialties concerning SVM, while also investigating sociodemographic factors associated with their KAP scores. These unique insights hold the potential to guide targeted improvements in the diagnosis and treatment of SVM, addressing a critical gap in medical knowledge and practice.

## METHODS

### Patient and public involvement

Doctor involvement played a significant role in this study. Doctors were engaged from the early stages, providing their expertise and insights to shape the research questions and outcome measures. Their involvement extended to the study design, where their feedback helped refine the methodology. Additionally, doctors actively participated in the recruitment process and contributed to the successful conduct of the study. While patients and the public may not have been directly involved, the study aimed to improve the knowledge and practices of doctors to ultimately benefit patients. The study results will be disseminated to participating doctors, ensuring they have access to relevant findings to enhance their clinical practice and patient care.

### Study design and participants

This cross-sectional study was conducted between 1 October 2022 and 1 December 2022, at the Department of Neurosurgery at the Second Affiliated Hospital of the Air Force Military Medical University (Xi'an, Shaanxi, China). The study enrolled full-time doctors who voluntarily participated. Approximately 3000 doctors from a total of 41 hospitals were screened, primarily located in northwest China. Recruitment was primarily facilitated through academic exchanges. Doctors who had participated in relevant advanced training (participate in relevant training organised by medical association or physician association at provincial level or above) or regular training (participate in a relevant intervention training every 3 months–6 months), and interns with limited experience were excluded to minimise potential bias. This study applied a random inclusion principle to select participants at various levels of education, including Bachelor's degree and below, Master's degree and Doctoral degree, with varying levels of experience.

### Questionnaire

A self-designed questionnaire was created by the authors based on the expert consensus regarding the diagnosis and treatment of SVM[1 10–12] and revised according to the opinions of three experts in neurosurgery and three experts in neurology. The questionnaire contained four parts, including demographic information of participants, KAP. Questions 7, 10 and 12 in knowledge parts were set as incorrect expressions to reflect a more realistic situation, while the other questions were set as correct expressions. Knowledge was scored between 0 and 12 (12 questions), with 1 point awarded for each correct answer and 0 point for each wrong or unclear answer. Attitude was scored from 6 to 30 points (6 questions), with 5 points for an extremely positive attitude and 1 point for an extremely negative attitude. The assessment of practice consisted of 15 questions. Due to the low incidence of SVM, we asked doctors from SVM-related departments (neurosurgery, orthopaedics and neurology) to answer 13 questions (PP1, PP2.1–PP2.7 and PP3.1–PP3.5) and doctors from other departments to answer 2 questions (P1 and P2). Answers 'yes' to PP1 received 5 point, whereas answers 'no' received 4 points. Except for PP3.2 and PP3.3, all other questions were scored on a 5-point Likert scale. 1=strongly disagree/very unlikely, 2=somewhat disagree/unlikely, 3=neither agree nor disagree/do not know/neutral, 4=somewhat agree/likely and 5=strongly agree/very likely. Practice scores of doctors from relevant departments ranged from 14 to 55, while those from other departments ranged from 2 to 10. A small-scale prerelease (36 copies) was conducted before the official launch of the questionnaire, producing a Cronbach's score of 0.850.

Electronic questionnaires were distributed via Wechat (Tencent, China) using a quick response (QR) code created by Wenjuanxing (Changsha Ranxing Information Technology Co.), an online questionnaire software platform.[13] By scanning the QR code, participants accessed, completed and submitted the questionnaire. Each IP address can only be submitted once, and all items must be completed to ensure the quality and integrity of the questionnaire results. The research team reviewed each questionnaire for completeness, internal coherence and plausibility. A higher score indicates a higher level of KAP.

### Statistical analysis

The statistical analysis was performed using Stata V.17.0 (Stata Corporation). Continuous data were expressed as mean±SD and compared by t-test and $\chi^2$ test. Categorical data were expressed as frequency (percentage) and compared with the $\chi^2$ test. The Pearson correlation was applied to analyse the correlation between KAP score. The association between sociodemographic

characteristics and knowledge and attitude was examined using univariate and multivariate logistic regression analyses. To examine the risk factors associated with knowledge and attitude, variables with p<0.02 were included in the multivariable logistic regression analysis, using a total score of 70th percentile as a cut-off point. The statistical tests were all two sided, and a p value of less than 0.05 was considered statistically significant.

## RESULTS

A total of 517 physicians participated in the survey, including 399 (77.18%) from Shaanxi, China (online supplemental figure S1). Among the participants, 396 (76.6%) worked in neurosurgery, orthopaedics and neurology departments directly related to SVM, and 121 (23.4%) worked in other departments. Table 1 shows the sociodemographics and knowledge and attitude scores of the participants. The mean knowledge score and attitude score were 9.66±1.95 (range: 0–12) and 22.16±1.71 (range: 6–30), and the practice scores for relevant and non-relevant departments were 46.13±5.35 (range: 14–55) and 8.50±1.25 (range: 2–10), respectively.

Knowledge scores significantly differed by sex, education level, job title, hospital classification and department (all p<0.05, table 1). Participants were least knowledgeable about whether endovascular therapy and diagnostic angiography can be performed simultaneously (correct rate=27.2%, table 2). There were significant differences in attitude scores based on education level, hospital classification and department (all p<0.01, table 1). Over 90% of participants responded positively to most of the questions except when asked about their little understanding of SVM's rarity and complexity (table 2). In the practice assessment, 96.69% of participants from other departments agreed with varying degrees that it is imperative to pay close attention to patients who develop SVM-related symptoms and to perform relevant examinations immediately to confirm the diagnosis. However, only 30.58% were very confident in identifying SVM and referring patients to a specialist (table 2). Participants from relevant departments performed well in taking appropriate actions when encountering a patient with suspected SVM or treating patients diagnosed with SVM and most of the participants (64.10%) had experience of treating patients with SVM (figure 1).

A positive correlation was found between knowledge and attitude, as well as between attitude and practice, among physicians from other departments (both p<0.05, online supplemental table S1). KAP were positively correlated among physicians from relevant departments (all p<0.001, online supplemental table S2). According to the multivariate logistic regression, a master's degree (OR=1.87, 95% CI 1.16 to 3.02, p=0.010) and a doctoral degree (OR=1.72, 95% CI 1.02 to 4.84, p=0.015) were independently associated with good knowledge. Knowledge (OR=1.72, 95% CI 1.11 to 2.65, p=0.015), a master's degree (OR=1.85, 95% CI 1.14 to 3.00, p=0.013) and working in orthopaedics (OR=0.34, 95% CI 0.13 to 0.88, p=0.026) were independently associated with good attitude (table 3). Univariate logistic regression analysis of practice showed that no variable was associated with good practice (online supplemental table S3).

## DISCUSSION

A descriptive review study has emphasised that clinicians should possess a strong awareness of SVM since they are often misdiagnosed or undertreated. Early recognition and specialist collaboration are crucial for accurate diagnosis and effective treatment. Proactive management is essential, as recent advancements in diagnostic imaging and therapies have improved patient outcomes.[14] However, there is a significant lack of KAP studies in this area. In this study, doctors showed good knowledge, moderate attitudes and good practice regarding SVM. KAP showed a significant positive correlation among doctors from the neurosurgery, orthopaedic and neurological departments. Having a higher level of education may lead to better knowledge. A good attitude was independently associated with good knowledge, a master's degree and working in orthopaedics.

Symptoms of SVM include gait disturbances, paraesthesia, diffuse sensory symptoms and radicular pain in the early stages; bowel and bladder incontinence, erectile dysfunction and urinary retention may develop later.[1] Several inherited conditions, including familial cutaneous haemangiomas, Kartagener's syndromes and hereditary haemorrhagic telangiectasia, have been linked to SVM, providing clues to early diagnosis of SVM.[15–17] Diagnostic and therapeutic interventions can be performed simultaneously in SVM.[18 19] Treatment of SDAF with simultaneous angiography and endovascular therapy can achieve a 70%–90% obliteration rate.[19] To better assess actual knowledge regarding the common symptoms, heritability and feasibility of concurrent angiography and endovascular therapy, we set questions 7, 10 and 12 as incorrect statements. Participants demonstrated adequate knowledge of other questions (correct rates>80%) but poor knowledge of the three deceptive questions (correct rates=42.55%, 41.78% and 27.27%, respectively). Thus, there is a need for participants to strengthen their knowledge in the relevant field.

In a review of more than 20 years of SVM management at three major centres for cerebrovascular disease in Canada, the authors found that the accumulated knowledge regarding embryological and pathophysiological aspects of SVM directly impacted the therapeutic options.[20] We found that KAP exhibited pairwise positive correlations in the doctors from the neurosurgery, orthopaedic and neurological departments. Doctors from other departments also showed positive correlations between knowledge and attitude and between attitude and practice. Multiple classifications and updates suggest the complexity of SVM and reflect the continued advancement of the understanding of SVM.[21 22] The management

**Table 1** Sociodemographic characteristics and knowledge, attitude and practice scores

| Variables | N (%) | Knowledge | | Attitude | | Practice of relevant departments* | | Practice of other departments | |
|---|---|---|---|---|---|---|---|---|---|
| | | Mean±SD | P value | Mean±SD | P value | Mean±SD | P value | Mean±SD | P value |
| **Total** | 517(100) | 9.66±1.95 | | 22.16±1.71 | | 46.13±5.35 | | 8.50±1.25 | |
| Sex | | | <0.001 | | 0.133 | | 0.359 | | 0.056 |
| Male | 391 (75.63) | 9.89±1.73 | | 22.23±1.75 | | 45.83±5.37 | | 8.61±1.83 | |
| Female | 126 (24.37) | 8.92±2.39 | | 21.94±1.54 | | 47.37±5.10 | | 8.35±1.34 | |
| Age (years) | | | 0.222 | | 0.294 | | 0.986 | | 0.589 |
| ≤40 | 277 (53.68) | 9.74±1.92 | | 22.24±1.76 | | 46.36±4.88 | | 8.56±1.03 | |
| >40 | 239 (46.32) | 9.56±1.99 | | 22.07±1.64 | | 45.74±5.97 | | 8.48±1.36 | |
| Education | | | <0.001 | | <0.001 | | 0.351 | | 0.903 |
| Bachelor's degree and below | 317 (61.32) | 9.37±1.97 | | 21.91±1.57 | | 46.10±5.52 | | 8.59±1.22 | |
| Master's degree | 162 (31.33) | 10.12±1.71 | | 22.51±1.83 | | 46.03±5.33 | | 8.15±1.38 | |
| Doctoral degree | 38 (7.35) | 10.05±2.29 | | 22.79±1.85 | | 46.71±4.18 | | 8.75±0.96 | |
| Job title | | | 0.049 | | 0.213 | | 0.916 | | 0.820 |
| Resident | 67 (12.96) | 9.51±2.13 | | 21.81±1.59 | | 46.15±5.63 | | 8.43±1.21 | |
| Attending physician | 232 (44.87) | 9.47±1.97 | | 22.12±1.70 | | 46.22±4.93 | | 8.56±1.10 | |
| Deputy chief physician | 173 (33.46) | 9.84±2.00 | | 22.34±1.79 | | 46.23±5.74 | | 8.43±1.50 | |
| Chief physician | 45 (8.70) | 10.11±1.13 | | 22.22±1.55 | | 45.40±5.52 | | 9.00±1.00 | |
| Years of work experience | | | 0.540 | | 0.452 | | 0.765 | | 0.337 |
| <5 | 45 (8.70) | 9.84±2.20 | | 22.13±1.67 | | 45.82±5.41 | | 8.43±0.98 | |
| 5–10 | 97 (18.76) | 9.72±1.74 | | 22.25±1.79 | | 46.15±5.22 | | 8.47±1.06 | |
| 10–15 | 152 (29.40) | 9.57±1.84 | | 22.12±1.66 | | 46.49±4.54 | | 8.36±1.39 | |
| 15–20 | 114 (22.05) | 9.75±1.83 | | 22.35±1.74 | | 46.68±6.05 | | 8.77±1.14 | |
| >20 | 109 (21.08) | 9.55±2.29 | | 21.95±1.67 | | 45.14±5.79 | | 8.39±1.38 | |
| Hospitals classification | | | <0.001 | | 0.004 | | 0.126 | | 0.974 |
| Public primary and secondary hospitals | 147 (28.43) | 9.02±2.24 | | 21.78±1.41 | | 46.08±5.91 | | 8.50±1.11 | |
| Public tertiary hospitals | 326 (63.06) | 9.97±1.77 | | 22.33±1.78 | | 46.14±5.24 | | 8.67±1.31 | |
| Private hospitals | 44 (8.51) | 9.43±1.70 | | 22.16±1.87 | | 46.18±4.33 | | 7.94±1.34 | |
| Department | | | <0.001 | | <0.001 | | 0.007 | | – |
| Neurosurgery | 203 (39.26) | 10.16±1.44 | | 22.45±1.73 | | 46.66±4.73 | | – | |
| Orthopaedics | 30 (5.80) | 8.80±2.99 | | 20.90±2.12 | | 42.37±7.85 | | – | |
| Neurology | 163 (31.53) | 9.83±1.65 | | 22.39±1.53 | | 46.15±5.27 | | – | |
| Others | 121 (23.40) | 8.79±2.36 | | 21.67±1.54 | | – | | – | |

*Relevant departments refer to SVM-related departments, including neurosurgery, orthopaedics and neurology.
SVM, spinal vascular malformations.

**Table 2** Knowledge, attitude and practice questionnaire

| Items for knowledge | N (%) Correct | Incorrect | Unclear |
|---|---|---|---|
| K1. SVM is a congenital abnormality of cerebrovascular development that can result in acute, subacute or chronic brain dysfunction. (Correct) | 495 (95.74) | 6 (1.16) | 16 (3.09) |
| K2. After a long course of the disease, patients with SVM develop severe neurological deficits and require neurosurgery. (Correct) | 474 (91.68) | 23 (4.45) | 20 (3.87) |
| K3. In adolescents, SVM is one of the most common causes of severe disability due to its low incidence, heterogeneity in onset and easy misdiagnosis. (Correct) | 472 (91.30) | 16 (3.09) | 29 (5.61) |
| K4. There are several types of SVM, including spinal dural arteriovenous fistula, spinal arteriovenous malformation, perimedullary arteriovenous fistula, epidural arteriovenous fistula and cavernous vascular malformation. (Correct) | 485 (93.81) | 7 (1.35) | 25 (4.84) |
| K5. Spinal angiography is the gold standard for the diagnosis of spinal cord vascular lesions, especially spinal dural arteriovenous fistulas, and arteriovenous malformations. (Correct) | 496 (95.94) | 5 (0.97) | 16 (3.09) |
| K6. Acute manifestations and long-term progressive neurological decline are the two types of clinical manifestations of SVM. (Correct) | 472 (91.30) | 12 (2.32) | 33 (6.38) |
| K7. All patients with SVM would experience symptoms of myelopathy, including lower extremity weakness, loss of pain and temperature sensation, and bladder and faecal incontinence. (Incorrect) | 220 (42.55) | 245 (47.39) | 52 (10.06) |
| K8. Neurogenic claudication is often associated with spinal dural arteriovenous fistulas, worsened by physical activities such as walking and standing and relieved by sitting. (Correct) | 414 (80.08) | 38 (7.35) | 65 (12.57) |
| K9. Spinal arteriovenous malformation most commonly causes subarachnoid, intraparenchymal or both types of bleeding. (Correct) | 470 (90.91) | 16 (3.09) | 31 (6.00) |
| K10. Spinal cavernous malformation is not inherited. (Incorrect) | 216 (41.78) | 175 (33.85) | 126 (24.37) |
| K11. Surgical or endovascular intervention of SVM can be used to stop or reverse disease progression by eliminating blood flow at abnormal fistula junctions and restoring normal spinal cord perfusion and intravascular pressure. (Correct) | 482 (93.23) | 4 (0.77) | 31 (6.00) |
| K12. Endovascular therapy and diagnostic angiography cannot be performed simultaneously. (Incorrect) | 141 (27.27) | 312 (60.35) | 64 (12.38) |

| Items for attitude | Extremely positive | Positive | Neutral | Negative | Extremely negative |
|---|---|---|---|---|---|
| A1. Despite its low incidence rate, spinal vascular malformation often leads to severe clinical symptoms and great harm. | 363 (70.21) | 141 (27.27) | 9 (1.74) | 3 (0.58) | 1 (0.19) |
| A2. Due to atypical clinical presentation, many patients with spinal vascular malformations are misdiagnosed and treated inappropriately. | 306 (59.19) | 193 (37.33) | 14 (2.71) | 3 (0.58) | 1 (0.19) |
| A3. The prognosis of spinal dural arteriovenous fistula can be greatly improved by early diagnosis and treatment before permanent spinal cord ischaemic injury occurs. | 362 (70.02) | 139 (26.89) | 14 (2.71) | 1 (0.19) | 1 (0.19) |
| A4. As soon as a spinal vascular malformation is diagnosed, it is imperative to seek timely and effective treatment. | 373 (72.15) | 123 (23.79) | 14 (2.71) | 6 (1.16) | 1 (0.19) |
| A5. Spinal vascular malformations are rare and complex, and I know little about them. | 140 (27.08) | 229 (44.29) | 95 (18.38) | 41 (7.93) | 12 (2.32) |
| A6. I would like to learn more about spinal vascular malformations. | 317 (61.32) | 182 (35.20) | 15 (2.90) | 2 (0.39) | 1 (0.19) |

Continued

**Table 2** Continued

| Items for practice | Extremely positive/ likely | Positive/ likely | Neutral | Negative/ unlikely | Extremely negative/ unlikely |
|---|---|---|---|---|---|
| **Other departments** | | | | | |
| P1. It is imperative to pay close attention to patients who develop severe low back pain, muscle weakness, and incontinence in a short period of time, and to carry out relevant examinations immediately to confirm the diagnosis. | 84 (69.42) | 33 (27.27) | 4 (3.31) | 0 | 0 |
| P2. I am confident that I can identify spinal vascular malformations and refer patients to a specialist. | 37 (30.58) | 40 (33.06) | 35 (28.93) | 6 (4.96) | 3 (2.48) |
| **SVM-related departments** | | | | | |
| PP1. Are you likely to recommend or take the following actions if you encounter a patient with suspected spinal vascular malformation? | | | | | |
| PP1.1 A complete physical examination (mainly the nervous system) | 308 (77.78) | 63 (15.91) | 19 (4.80) | 5 (1.26) | 1 (0.25) |
| PP1.2 Assessment of symptoms (sensation and motor dysfunction, incontinence, severe back pain, etc) | 310 (78.28) | 70 (17.68) | 14 (3.54) | 0 | 2 (0.51) |
| PP1.3 Spinal cord MRI | 334 (84.34) | 43 (10.86) | 14 (3.54) | 3 (0.76) | 2 (0.51) |
| PP1.4 Spinal cord computed tomographic angiography or magnetic resonance angiography | 261 (65.91) | 68 (17.17) | 46 (11.62) | 13 (3.28) | 8 (2.02) |
| PP1.5 Plain X-rays | 66 (16.67) | 55 (13.89) | 148 (37.37) | 58 (14.65) | 69 (17.42) |
| PP1.6 Spinal cord angiography | 285 (71.97) | 60 (15.15) | 30 (7.58) | 13 (3.28) | 8 (2.02) |
| PP1.7 Lumbar puncture | 97 (24.49) | 80 (20.20) | 124 (31.31) | 47 (11.97) | 48 (12.12) |
| PP2. In clinical practice, are you likely to treat patients diagnosed with the following diseases with the following treatments? | | | | | |
| PP2.1 Dural arteriovenous fistula: surgery | 148 (37.37) | 92 (23.23) | 83 (20.96) | 39 (9.85) | 34 (8.59) |
| PP2.2 Spinal arteriovenous malformation: surgery | 123 (31.06) | 102 (25.76) | 98 (24.75) | 40 (10.10) | 33 (8.33) |
| PP2.3 Spinal arteriovenous malformation: embolisation | 219 (55.30) | 121 (30.56) | 29 (7.32) | 10 (2.53) | 17 (4.29) |
| PP2.4 Spinal arteriovenous fistula: embolisation | 217 (54.80) | 121 (30.56) | 33 (8.33) | 7 (1.77) | 18 (4.55) |
| PP2.5 Cavernous malformation: surgery | 189 (47.73) | 98 (24.75) | 66 (16.67) | 19 (4.80) | 24 (6.06) |

Doctors from SVM-related departments (neurosurgery, orthopaedics and neurology) answered 12 questions (PP1.1–PP1.7 and PP2.1–PP2.5) and doctors from other departments answered two questions (P1 and P2).
Answers 'yes' to PP1 received 1 point, whereas answers 'no' received 0 point.
With the exception of PP3.2 and PP3.3, all other questions were scored on a 5-point Likert.
SVM, spinal vascular malformations.

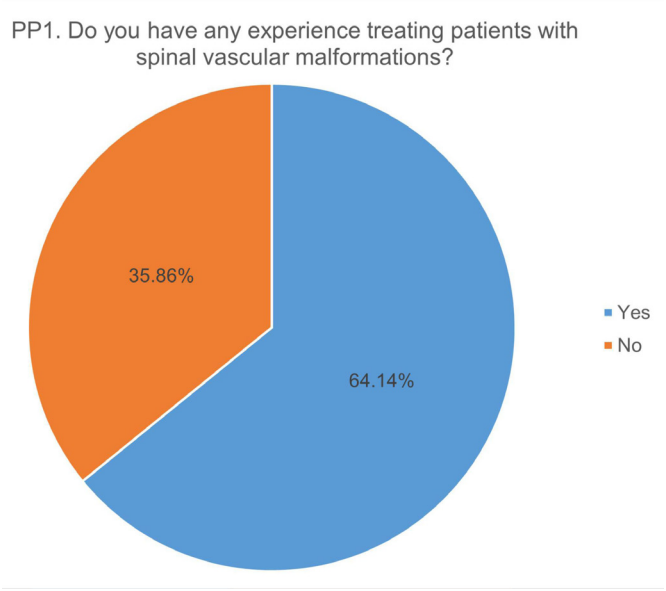


**Figure 1** The distribution of attitude: PP1 Do you have any experience treating patients with spinal vascular malformations?

of SVM may be positively impacted by gaining new physiological and genetic knowledge. However, only 70% of the participants expressed positive attitudes about their lack of understanding of SVM rarity and complexity, compared with over 90% for other questions. For better practice in SVM management, a more positive attitude is needed.

Timely multidisciplinary teamwork is crucial to reducing misdiagnosis and avoiding inappropriate treatment in SVM. Approximately 70% of patients with SDAVF were primarily diagnosed after multidisciplinary teamwork.[23] Thus, our study included physicians from other departments as well as the directly relevant departments. Based on the practice assessment, 96.69% of doctors from other departments were aware of SVM symptoms and the urgency for immediate examination, but only 30.58% were confident about identifying SVM. Doctors from other departments may be more confident in recognising SVM when they have more knowledge about it.

While angiography remains the gold standard for SVM diagnosis, MRI and MRA are promising complementary tools for detecting and characterisation of SVM. When a spinal cord lesion is suspected, an MRI is usually the first test performed.[4 24 25] We found that over 80% of physicians working in the relevant departments were very likely or likely to recommend or perform MRI, MRA or angiography for patients with suspected SVM, suggesting a good practice regarding the diagnosis of SVM. SVM can be treated with surgery, endovascular embolisation, or a combination of both, depending on the type and location of the lesion.[26 27] Our results showed that most doctors preferred embolisation over surgery. However, indications, efficacy and safety of embolisation vary among different types of SVM and should be evaluated carefully for each patient.[28]

**Table 3** Multivariate logistic regression analysis of relevant departments

| Variables | Multivariate logistic regression | |
|---|---|---|
| | OR (95% CI) | P value |
| **Knowledge** | | |
| Gender | | |
| Male | Ref. | |
| Female | 0.59 (0.31 to 1.09) | 0.090 |
| Education | | |
| Bachelor's degree and below | Ref. | |
| Master's degree | 1.87 (1.16 to 3.02) | 0.010 |
| Doctoral degree | 2.22 (1.02 to 4.84) | 0.045 |
| Hospitals classification | | |
| Public primary and secondary hospitals | Ref. | |
| Public tertiary hospitals | 1.26 (0.72 to 2.21) | 0.408 |
| Private hospitals | 0.65 (0.25 to 1.73) | 0.391 |
| Department | | |
| Neurosurgery | Ref. | |
| Orthopaedics | 0.63 (0.28 to 1.44) | 0.276 |
| Neurology | 0.75 (0.47 to 1.20) | 0.226 |
| **Attitude** | | |
| Knowledge score | | |
| <70% | Ref. | |
| ≥70% | 1.72 (1.11 to 2.65) | 0.015 |
| Education | | |
| Bachelor's degree and below | Ref. | |
| Master's degree | 1.85 (1.14 to 3.00) | 0.013 |
| Doctoral degree | 1.40 (0.63 to 3.09) | 0.407 |
| Job title | | |
| Resident | Ref. | |
| Attending physician | 1.50 (0.72 to 3.09) | 0.277 |
| Deputy chief physician | 1.95 (0.92 to 4.14) | 0.083 |
| Chief physician | 1.34 (0.53 to 3.38) | 0.532 |
| Hospitals classification | | |
| Public primary and secondary hospitals | Ref. | |
| Public tertiary hospitals | 1.30 (0.75 to 2.25) | 0.358 |
| Private hospitals | 1.13 (0.45 to 2.85) | 0.793 |
| Department | | |
| Neurosurgery | Ref. | |
| Orthopaedics | 0.34 (0.13 to 0.88) | 0.026 |
| Neurology | 1.27 (0.81 to 1.97) | 0.295 |

Since this is a cross-sectional study, it is difficult to derive causal relationships. In this study, data were collected by self-reporting, which might be less reliable than medical records and laboratory measurements due

to self-reporting bias. Additionally, since 77.18% of the participants were from Shaanxi, China, the results do not reflect the KAP of SVM nationwide. More studies in more areas with larger sample sizes are needed to better understand the KAP of SVM nationwide or worldwide.

## CONCLUSION

In this study, the KAP of Chinese clinical practitioners regarding the diagnosis and treatment of SVM were evaluated. Although participants had adequate knowledge, moderate attitudes and good practice regarding SVM, further education is needed to improve their attitudes and practices.

**Contributors** ZY, LF and DX carried out the studies, participated in collecting data and drafted the manuscript. JM and YH performed the statistical analysis and participated in its design. JL and YL participated in acquisition, analysis or interpretation of data and drafted the manuscript. YL acted as the guarantor of the manuscript. All authors read and approved the final manuscript.

**Funding** This work was supported by the Science Foundation for Distinguished Young Talents in Tangdu Hospital of the Air Force Military Medical University (2023CTDQN005).

**Competing interests** None declared.

**Patient and public involvement** Patients and/or the public were not involved in the design, or conduct, or reporting, or dissemination plans of this research.

**Patient consent for publication** Consent obtained directly from patient(s).

**Ethics approval** This study was approved by the Ethics Committee of the Second Affiliated Hospital of the Air Force Military Medical University (approval No. TDLL-202303-05). Participants gave informed consent to participate in the study before taking part.

**Provenance and peer review** Not commissioned; externally peer reviewed.

**Data availability statement** Data are available upon reasonable request. All data generated or analysed during this study are included in this published article (and its supplementary information files).



**ORCID iD**

Yufeng Liu http://orcid.org/0009-0002-1554-3756

## REFERENCES

1 Akgun MY, Kemerdere R, Ulu MO, *et al*. Spinal vascular malformations: treatment and outcome. *World Neurosurg* 2019;130:e953–60.
2 Marcus J, Schwarz J, Singh IP, *et al*. Spinal dural arteriovenous fistulas: a review. *Curr Atheroscler Rep* 2013;15:335.
3 Takai K. Spinal arteriovenous shunts: angioarchitecture and historical changes in classification. *Neurol Med Chir (Tokyo)* 2017;57:356–65.
4 Maimon S, Luckman Y, Strauss I. Spinal dural arteriovenous fistula: a review. *Adv Tech Stand Neurosurg* 2016;2016:111–37.
5 Ehresman J, Catapano JS, Baranoski JF, *et al*. Treatment of spinal arteriovenous malformation and fistula. *Neurosurg Clin N Am* 2022;33:193–206.
6 Brinjikji W, Nasr DM, Morris JM, *et al*. Clinical outcomes of patients with delayed diagnosis of spinal dural arteriovenous fistulas. *AJNR Am J Neuroradiol* 2016;37:380–6.
7 Ronald AA, Yao B, Winkelman RD, *et al*. Spinal dural arteriovenous fistula: diagnosis, outcomes, and prognostic factors. *World Neurosurg* 2020;144:e306–15.
8 Lev N, Maimon S, Rappaport ZH, *et al*. Spinal dural arteriovenous fistulae--a diagnostic challenge. *Isr Med Assoc J* 2001;3:492–6.
9 Andrade C, Menon V, Ameen S, *et al*. Designing and conducting knowledge, attitude, and practice surveys in psychiatry: practical guidance. *Indian J Psychol Med* 2020;42:478–81.
10 Oldfield EH. Introduction: spinal vascular malformations. *Neurosurg Focus* 2009;26:E1.
11 Flores BC, Klinger DR, White JA, *et al*. Spinal vascular malformations: treatment strategies and outcome. *Neurosurg Rev* 2017;40:15–28.
12 Sabayan B, Lineback C, Viswanathan A, *et al*. Central nervous system vascular malformations: a clinical review. *Ann Clin Transl Neurol* 2021;8:504–22.
13 Guo C, Hu B, Guo C, *et al*. A survey of pharmacogenomics testing among physicians, pharmacists, and researchers from China. *Front Pharmacol* 2021;12:682020.
14 Rabinstein AA. Vascular myelopathies. *Continuum (Minneap Minn)* 2015;21:67–83.
15 Barnard E, Johnson T, Ngo T, *et al*. Porphyrin production and regulation in cutaneous propionibacteria. *mSphere* 2020;5.
16 Kaplan P, Hollenberg RD, Fraser FC. A spinal arteriovenous malformation with hereditary cutaneous hemangiomas. *Am J Dis Child* 1976;130:1329–31.
17 Hayakawa T, Kondoh T, Watanabe M, *et al*. Spinal arteriovenous malformation with kartagener's syndrome. *Surg Neurol* 1980;13:463–7.
18 Zimmerman P, d'Audiffret A, Pillai L. Endovascular repair of blunt extremity arterial injury: case report. *Vasc Endovascular Surg* 2009;43:211–4.
19 Lee HS, Kang H-S, Kim SM, *et al*. Treatment strategy to maximize the treatment outcome of spinal dural arteriovenous fistula after initial endovascular embolization attempt at diagnostic angiography. *Sci Rep* 2021;11.
20 da Costa L, Dehdashti AR, terBrugge KG. Spinal cord vascular shunts: spinal cord vascular malformations and dural arteriovenous fistulas. *Neurosurg Focus* 2009;26:E6.
21 Abecassis IJ, Osbun JW, Kim L. Classification and pathophysiology of spinal vascular malformations. *Handb Clin Neurol* 2017;143:135–43.
22 McCuaig CC. Update on classification and diagnosis of vascular malformations. *Curr Opin Pediatr* 2017;29:448–54.
23 Yang B, Lu T, He X, *et al*. Spinal dural arteriovenous fistula: a rare but treatable disease that should not be missed by orthopedic surgeons. *Front Neurol* 2022;13:938342.
24 Amarouche M, Hart JL, Siddiqui A, *et al*. Time-resolved contrast-enhanced MR angiography of spinal vascular malformations. *AJNR Am J Neuroradiol* 2015;36:417–22.
25 Condette-Auliac S, Boulin A, Roccatagliata L, *et al*. MRI and MRA of spinal cord arteriovenous shunts. *J Magn Reson Imaging* 2014;40:1253–66.
26 Singh B, Behari S, Jaiswal AK, *et al*. Spinal arteriovenous malformations: is surgery indicated? *Asian J Neurosurg* 2016;11:134–42.
27 Marchitto MC, Chien AL. Mast cell stabilizers in the treatment of rosacea: a review of existing and emerging therapies. *Dermatol Ther (Heidelb)* 2021;11:1541–9.
28 Therapeutic N, American Society for I. Embolization of spinal arteriovenous fistulae, spinal arteriovenous malformations, and tumors of the spinal axis. *AJNR Am J Neuroradiol* 2001;22:S28–30.