Considering Psychological and Cognitive Factors in Interventional Neuroradiology: A Systematic Literature Review

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ABSTRACT

BACKGROUND: Interventional neuroradiology is a relatively recent discipline that diagnoses and treats cerebral vascular diseases. However, specific literature on cognitive and psychological domains of patients undergoing interventional neuroradiology procedures is limited.

PURPOSE: Our aim was to review the existent literature on cognitive and psychological domains in patients undergoing interventional neuroradiology procedures to raise clinicians' awareness of their mental status.

DATA SOURCES: Articles were searched in PubMed, EMBASE, and Scopus from 2000 to 2022 using terms such as "interventional neuroradiology," "psychology," and "cognition" according to Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines.

STUDY SELECTION: Of 1483 articles in English, 64 were included and analyzed. Twelve focused on psychological aspects; 52, on cognitive ones.

DATA ANALYSIS: Regarding psychological aspects, it appears that early psychological consultations and "nonpharmacologic" strategies can impact the anxiety and depression of patients undergoing endovascular procedures. Regarding cognitive aspects, it appears that endovascular treatment is safe and generates similar or even fewer cognitive deficits compared with analogous surgical procedures.

DATA SYNTHESIS: Among the 12 articles on psychological aspects, 6/12 were retrospective with one, while 6/12 were prospective. Among the 52 articles on cognitive aspects, 7/54 were retrospective, while 45/52 were prospective.

LIMITATIONS: The main limitation derives from the inhomogeneity of the cognitive and psychological assessment tools used in the articles included in our analysis.

CONCLUSIONS: Our review highlights the need to include cognitive and psychological assessments in clinical practice in case patients eligible for interventional neuroradiology procedures. In the future, much more research of and attention to cognitive and psychologic aspects of neurovascular disease is needed. Systematic incorporation of strategies and tools to access and address pre, peri-, and postprocedural psychological and cognitive components could have major benefits in patient satisfaction, recovery, and the success of endovascular practice.

ABBREVIATIONS: CAS = carotid artery stent placement; DAVF = dural arteriovenous fistula; EC = endovascular coiling; INR = interventional neuroradiology; QoL = quality of life; RCT = randomized control trial; RIA = ruptured intracranial aneurysm; SC = surgical clipping; UIA = unruptured intracranial aneurysm

The number of patients with vascular disease undergoing diagnostic and therapeutic neuroangiography procedures has increased during the past decades.[1] Studies of neurovascular interventions have focused primarily on morbidity/mortality, clinical deficiency, and disability. However, it is increasingly recognized that many neurovascular patients may have cognitive and psychological impairments that contribute to a decrease in their quality of life (QoL). It is a common experience that patients who have undergone neurovascular procedures do not feel a "real

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recovery,"[2] even when they achieve complete anatomic cure. Unfortunately, these difficulties are not adequately assessed by standard clinical scales (ie, mRS, Glasgow Outcome Scale).[3,4]

We believe that a review of the existent literature can be helpful in raising clinicians' awareness of a patient's mental status and to recognize possible related psychological and cognitive changes.[5,6]

Being hospitalized is an unpleasant situation for most patients. Besides their illness, they must deal with several stressful experiences, including invasive vascular procedures.[7] Among these procedures, angiography is the criterion standard test for visualizing the neurovascular anatomy and understanding the complexity of cerebral circulation. However, due to its invasive nature and the risk of catheter-related injury, it represents a triggering experience causing anxiety. Furthermore, the level of anxiety and the ability to cope with it can influence the patient's physiologic status (eg, respiratory and heart rates, blood pressure).[8] In addition, excessive stress during cerebral angiography could limit the patient's ability to follow instructions during critical phases of the procedure.[8] Consequently, physiologic and psychological reactions may even increase the length of the procedure and the amount of sedation required. Moreover, even in the presence of favorable clinical outcomes and technically successful treatments, the mere presence of a CBV disease often results in some mental health impairment due to CBV symptoms or maladaptive coping with diagnostic tests and treatments.[5,9,10] Therefore, all these aspects should be seriously considered because they influence not only the patient's well-being and compliance with future follow-up but also the safety and efficacy of the procedure.

Unfortunately to date, patients with CBV disease rarely receive adequate psychological consultation as a standard medical service.[11]

When a vascular disease involves eloquent neuronal areas or determines specific hemodynamic changes, it can affect cognitive functions such as language, attention, information-processing speed, memory and executive and visuospatial abilities. These capacities are not always clinically detectable by simple routine functional scales, as mentioned above.[12-14]

Beyond the neurocognitive deficits caused by the illness itself, such as in SAH and vasospasm, a preventive treatment (endovascular or surgical) of an unruptured intracranial aneurysm (UIA) may carry risks of cognitive morbidities.[15,16]

Moreover, in case of cerebral arteriovenous shunt diseases, such as AVMs or dural arteriovenous fistulas (DAVFs), cognitive impairment is part of the natural clinical presentation of the disease, due to long-standing cerebral venous engorgement and edema. Clinical improvement can be achieved by solving cerebral vascular congestion, though the cognitive aspects of this process are often not adequately investigated.[17-19]

MATERIALS AND METHODS

Search Strategy

The review was conducted according to the latest available Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines.[20] PubMed, EMBASE, and Scopus were searched from January 2000 to July 2022 using medical subject headings and free text related to cerebrovascular diseases (ie, "aneurysm," "AVM," "DAVF," "interventional neuroradiology," and "psychology"). Specific search terms and strings are listed in the Online Supplemental Data.

We included studies in English with an abstract, which were indexed by at least one of the websites. Selection was based on the following eligibility criteria: 1) clinical studies; 2) a sample composed of patients with neurovascular disease; 3) patients undergoing a neuroradiology procedure, both diagnostic and therapeutic; 4) assessment of cognitive or psychological outcomes related to the procedure; and 5) no limitation on the duration of postprocedural outcome assessment.

Articles that considered only clinical or medical outcomes or only age as a sociodemographic variable and treatment other than interventional neuroradiology (INR) were not accepted. Exclusion criteria were the following: 1) not related to the addressed topic, such as not considering a neurovascular or cerebrovascular population; 2) psychological or cognitive variables not related to the INR procedure; 3) neuro- or radiosurgical procedure only; 4) merely medical variables taken into consideration; and 5) considered variables related only to general QoL measurements, not specifically cognitive or psychological ones.

Article Selection and Data Extraction

All abstracts were assessed by 1 researcher to check the inclusion criteria, and 20% of them were double-checked by other researchers who were unaware of the first one's conclusion. By means of the same process, the full texts were screened. All points of contention among the reviewers were discussed to obtain a consensus. The following information was obtained from each study: study design, study population characteristics, postoperative outcome data collected (sociodemographic, cognitive, and psychological), as well as the appropriate assessment scales, timing of the outcome assessment and follow-up, and pertinent study findings. The methodologic quality of all the selected studies was evaluated using the Newcastle-Ottawa Scale,[21] a well-established quality-assessment tool. All selected studies were high-quality articles based on the criteria and cutoff of the Newcastle-Ottawa Scale. Consistent with other literature,[2,6] a study was evaluated as high quality if at least 60% of the criteria were met (total score of $\geq$5 of 8).

RESULTS

The results of the study selection are shown in a study flow chart (Figure). Of 1483 records, 873 studies were removed because they were duplicates or case studies or reviews or not fully published in English. Thus, we screened 610 abstracts. Most of the articles ($n = 404$) were excluded during the abstract screening because they did not deal with the aim of the review; for instance, the population studied was not affected by a neurovascular or cerebrovascular pathology (reason 1). Thus, 206 records were sought for retrieval, and 15 were excluded because the full text was not available. One hundred ninety-one full-text articles were assessed for eligibility, of which 127 articles were excluded at the full-text screening for the following reasons: 39 because the outcomes/variables of interest were not evaluated in relation to neuroradiologic interventions or procedures (reason 2); 24 because the procedures were surgical or radiosurgical only (reason 3); 51 because they

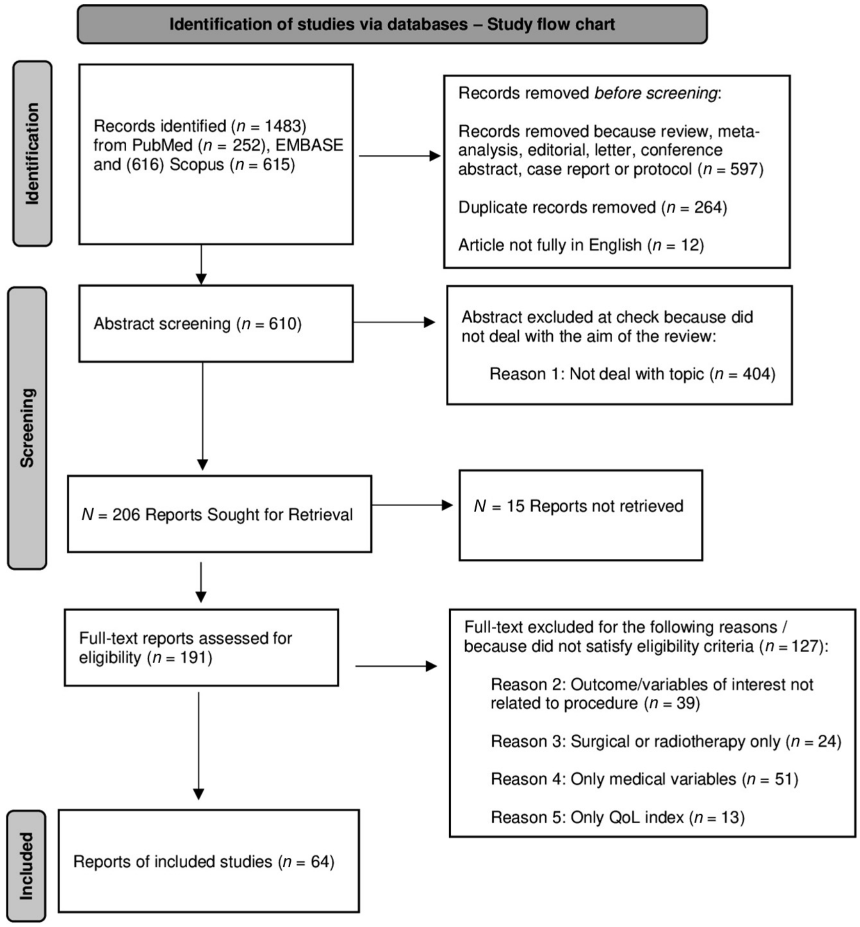

FIGURE. PRISMA study selection diagram. Study flow chart.

used only medical variables (reason 4); and 13 because only general variables on QoL were taken into account (reason 5). Finally, a total of 64/1483 (4%) articles met our inclusion criteria.

Of the 64 articles, 12 investigated only psychological variables, particularly depression, anxiety, and stress symptoms, while 4 also contained QoL measures.[6,7,9,11,21-27] Moreover, 52 articles evaluated cognitive domains: general cognitive functioning, language, attention, processing speed, executive function, and learning and memory and visual construction. Each study could evaluate >1 type of outcome.

The included articles were grouped into 2 different tables. The Online Supplemental Data Table S1 list the articles[6,7,9-11,21-27] focused on psychological outcomes ($n = 12$), whereas the Online Supplemental Data Table S2 list the articles focused on cognitive investigation ($n = 52$). The second table is split into subgroups according to the different neurovascular procedures and conclusions. The Online Supplemental Data Table S2a include articles ($n = 9/52$) that do not report cognitive differences in outcomes of cerebral aneurysm procedures treated by endovascular coiling (EC) versus surgical clipping (SC).[13,28-35] The Online Supplemental Data Table S2b include articles ($n = 11/52$) that find a better cognitive outcome after EC versus SC.[3,36-45] The Online Supplemental Data Table S2c include articles ($n = 15/52$) that simply examine endovascular treatment outcomes without any comparison with other invasive techniques (eg, aneurysm, acute stroke, vascular malformation).[4,17,46-58] Finally, the Online Supplemental Data Table S2d include articles ($n = 17/52$) that specifically consider carotid stent placement or endarterectomy in patients with vessel stenosis.[12,59-74]

Of the 12 articles that explored psychological aspects (Online Supplemental Data Table S1), 6/12 were retrospective with one focused on MR imaging, while 6/12 were prospective with 2 randomized control trials (RCTs). Overall, anxiety and depression were the most considered symptoms, mainly measured with the State and Traits Anxiety Inventory and the Hamilton Anxiety and Depression Scale.[7,9,10,22-24]

In general terms, the main result from retrospective studies focused on UIAs (3/6:1/3 INR and SC treated versus untreated, and 2/3 EC or SC versus controls) is the good acceptance of a psychological consultation in case of severe psychological symptoms. From the retrospective studies on ruptured aneurysms (RIAs) (2/6 INR versus SC), the main result is that finding a new aneurysm in recently treated patients with RIAs does not affect their level of anxiety and depression. In the only retrospective observational MR imaging study in which patients with RIAs treated with SC versus EC were compared, the former presented with a higher occurrence of mood disorders, associated with hippocampal neuronal loss on MR imaging-DTI.[9]

The last of the restrospective studies, focusing on various CBV diseases, surgically or endovascularly treated, demonstrates mental health impairment within 30 days of the procedure, with normalization at 6-month follow-up.

Among the 6 prospective studies included, 1/5 was an RCT,[24] and 5/6 discussed the effect of nonpharmacologic interventions before and during diagnostic angiography.[7,23-26] Only in 3 of them did discussing multimedia-based information, room-orientation tour, and music before the procedure demonstrate a reduction in the patient's anxiety.

The main results obtained from our analysis of the 54 articles focused on cognitive aspects are listed below.

The first cluster (Online Supplemental Data Table S2a) comprises articles showing similar cognitive outcomes in patients, regardless of treatment (EC or SC).[13,28-35] In 9/54 studies, one was retrospective[28] and 8 were prospective, including 1 RCT. All 9 studies dealt with patients with RIAs, except for 1 prospective study involving patients with UIAs.[35] The only retrospective study on patients with RIAs did not show any clear differences between EC versus SC at the 2-year follow-up.[28] Regarding the prospective analysis of patients with RIAs, 4/8 studies[13,30,32,33] demonstrated no score differences at 12-month postprocedural evaluation, even in patients with a good clinical recovery. Similar conclusions emerged from the more recent studies assessing cognitive outcome at 6-month postintervention.[13,29] Similarly, no cognitive differences between the SC and EC groups were demonstrated in patients with UIAs.[35]

The second cluster (Online Supplemental Data Table S2b) comprises articles showing better cognitive outcomes in patients with EC versus SC. In 11/54 studies, one was retrospective,[36] while 10 were prospective[3,37-45] and 2 of them were randomized.[41,42] All the studies included patients with RIAs, despite 3 prospective studies that involved patients with UIAs.[43,45,47] The only retrospective article demonstrated that patients undergoing EC had fewer cognitive deficits at 12 months, probably due to the more invasive nature of SC. In the 10 prospective studies, 7 following SAH showed worse performance of SC compared with the EC group on auditory-verbal/visuospatial memory,[37] frontal functions,[38] and general cognitive status.[2] The better cognitive outcome of the EC group was more evident in the acute phase after treatment (within 2 weeks) than in the long term (6 months).[39] The only study that compared the pre- and posttreatment assessment, also confirmed this result.[40] The same outcome emerged from the 2 RCTs performed on 181 patients with RIAs, with follow-up at 3 and 12 months. In 1 RCT, an additional investigation with voxel-based morphometry, MR imaging was performed, which showed significant gray matter atrophy in the SC group at 1 year.[41] Among the 3 prospective studies on UIAs, the largest available study was the neuropsychological substudy (474 patients) of the International Subarachnoid Trial (ISAT), which confirmed a greater cognitive impairment in the SC group at 12 months, also intriguingly evident in patients not disabled at mRS (Modified Ranking Scale).[43]

The third cluster (Online Supplemental Data Table S2c) includes 15 studies on patients treated by endovascular means only, for cerebral aneurysm, acute stroke, or vascular malformation (7/15 with EC, 1/15 with a flow diverter, 1/15 with various devices such as coils, stents, flow diverters and intrasaccular web, 4/15 with endovascular mechanical thrombectomies, 2/15 using glue in AVMs or DAVFs). Among them, 11/15 studies included prospective analysis, and in 5/11, a pre- and posttreatment cognitive status assessment was performed.[50,51,53,54,58] Only 1/15 was an RCT.[5-7] The 4 retrospective studies[17,49,52,56] involved patients with RIAs (1/4)[49] and patients with UIAs (1/4),[52] patients with endovascular treatment (1/4),[56] and patients with AVMs (1/4).[17] In this cluster, 3 studies implemented additional imaging investigations (DWI, fMRI, resting-state fMRI).[17,50,58]

Among the 6/15 studies on patients undergoing EC, 4/6 focused on RIAs,[29,47-49] while 2/6 focused on patients with UIAs.[50,51] In the first group, memory functions resulted in less impairment than executive functions,[47] and mild cognitive impairment, this was independently associated with aneurysm location.[48] In addition, SAH may cause cognitive impairment as a late outcome for decades, even after a successful treatment and a good mRs at discharge.[49] Bründl et al,[46] in 2018, suggested that an excessive release of endogenous neuropeptide Y in the CSF can be responsible for this phenomenon. Regarding patients with UIAs, endovascular coiling results to be safe, without any significant impact on neurocognitive functioning,[51] even when new devices such as flow divertors (1/15) or other hypothetically highly thrombogenic devices (1/15) are used.[54]

In general terms, carefully monitored anesthesia contributes to improved postoperative cognitive outcomes.[52,53]

The 4/15 articles investigating patients with acute stroke treated by mechanical thrombectomy, alone or in combination with thrombolysis,[3,56] demonstrated that mechanical thrombectomy improves cognitive performance.[55,57]

The 2/15 articles in this group using advanced fMRI highlighted possible rearrangements of the neuronal network related to cognitive decline and potential recovery after treatment in patients with cerebrovascular malformations (AVMs and DAVFs).[17,58]

The fourth cluster (Online Supplemental Data Table S2d) includes 17 studies focused on the neuropsychological changes after carotid artery stent placement (CAS) or endarterectomy; only one was retrospective.[59] Among the prospective ones, 4/17 had additional imaging assessment.[59,60,71,72] Cases of chronic ICA occlusion revascularization were considered in 2/16 prospective studies, while 4 cases of intracranial stent placement were included in the retrospective study.

All the studies, except for 1 prospective study,[63] agreed on the evidence of a cognitive improvement after CAS, due to a global cerebral perfusion amelioration.[12,59,62,65,68,70,74,75]

Remarkably, in the studies comparing CAS and endarterectomy, no significant differences in cognitive outcomes between groups were detected.[64,70,72,73] Even the only RCT study in this group demonstrated no differences between CAS and endarterectomy groups in verbal and nonverbal memory, attention, and executive functioning.[73]

Two of 4 imaging studies revealed that cognitive improvement after CAS could be related to a perfusion amelioration.[59,72] However, Corriere et al[60] reported in their series that 2/8 patients with CAS who had undergone MR imaging presented with cognitive deficits despite increased perfusion values without detectable microembolization. The last imaging study, which correlated enhancing atherosclerotic plaques with intraprocedural cerebral ischemic lesions and cognitive impairment, revealed that enhancing unstable plaque was strongly associated with new lesions on DWI, even without any cognitive deficit.[71]

DISCUSSION

In this section, we discuss salient results and research gaps in the literature reviewed.

For ease of reading, this section is divided according to the content of the Tables (Online Supplemental Data Tables S1 and S2a–d).

Articles Focused on Psychological Factors

Interestingly enough, the level of anxiety and depression was not significantly different in the articles comparing the psychological impact in patients with treated-versus-untreated aneurysms (Online Supplemental Data Table S1).[10,22]

When different CBV diseases are studied, patients who self-reported high levels of depression and anxiety generally reverted to the normal range at 6-month follow-up.[21] These results suggest that an early psychological consultation can be relevant in improving patients' short-term outcomes.[11]

A strong limitation of the retrospective studies included in this section is a lack of preoperational baseline evaluations. This omission can explain the low level of QoL found in retrospective studies, which may have been pre-existing and not related to diagnosis or treatment.[6]

Instead, the patients' baseline statuses were always assessed in the prospective analyses. Among these, studies on nonpharmacologic interventions give the general impression that the multimedia information session,[23,24] orientation in the room,[2,6] or musical intervention[7,25] positively interfered with anxiety and physiologic stress reduction. Nevertheless, due to the inhomogeneity of the samples in terms of pathology, timing, and treatment methods, some results remain conflicting.

In practice, these management strategies are difficult to implement because they are highly time- and resource-consuming. Further investigations in this field of INR are advisable, similar to what has already widely occurred in cardiovascular research.[75]

In the only prospective RCT comparing endovascular treatment versus IVT in patients with acute stroke, the distribution of depression scores in patients receiving endovascular therapy was significantly better than that in the medical arm. However, the authors themselves hypothesized that survival of a potentially lethal neurologic event following a new endovascular therapy could have positively influenced the outcome of these patients per se.

In summary, all the studies included in our research agree that early psychological consultations[6,11,21] and behavioral interventions[7,23-26] can potentially impact the management of anxiety and depression in subjects undergoing diagnostic or therapeutic procedures.[10] Remarkably, although treatment for anxiety and depression will not alleviate functional deficits, it still improves QoL.[76] This outcome should be remembered in developing strategies for psychological care.[77]

From a methodologic point of view, we noted several limitations mainly related to the inhomogeneity in the CBV sample and in the controls, which were often pathologic (eg, spinal diseases). These limitations add confounding variables when trying to draw conclusions.[6,7,11,23-26]

Additionally, we observed that very few studies compared the psychological statuses of INR patients with surgical patients.[6,9,22] This gap should be addressed in future studies.

Only 1 study in this section made an additional observation associating anxiety and depression with neuroimaging findings (MR imaging-DTI).[9] Further investigations are needed to investigate the correlation between neuroimaging and psychological outcome.

Finally, from our review, we found that the most commonly used questionnaire to evaluate QoL was the 36-item Short Form Health Survey (SF-36), which has been recommended to study vascular disease[78] due to its simplicity and quick self-administration.[10] However, we believe that given the general nature of the SF-36 tool, neurovascular patients would benefit from the most specific neuro-QoL questionnaire.[22]

Articles Focused on Cognitive Factors

After treatment, some patients may experience varying degrees of cognitive changes in different domains, such as memory, attention, language, executive functions, and general cognition (Online Supplemental Data Table S2). Cerebral perfusion and blood flow modifications are part of the pathophysiologic basis of the altered cognitive status, with an impact on QoL and thus on work, family, and social interaction.[42]

These factors partly explain the divergent results obtained from the analysis of the first 2 clusters of articles, both focused on EC-versus-SC treatment outcomes (Online Supplemental Data Table S2a-b).

For instance in subjects with RIAs, the SAH grade, the occurrence of vasospasm, or the need for a ventricular shunt are all independent predictors of clinical recovery, but they are not always systematically considered.[30] Furthermore, the preoperational assessment is often missing (15/20), though it is fundamental for determining cognitive changes after an intervention and for correctly comparing different groups (EC versus SC). The few studies enrolling only subjects with UIAs with pretreatment controls showed similar results in both groups at 1-year follow-up, suggesting that the cognitive differences are prevalent in the short term after treatment, favoring the EC approach.[29,35,45] In the RIA group, pretreatment assessment was performed in only 2 studies of the second cluster (EC better than SC); therefore, confrontation with the first cluster was inherently limited.[40,42] Additionally, the time of follow-up assessment was inhomogeneous among different studies even inside the same clusters, adding difficulty to the interpretation of the results. The randomization of EC or SC samples would have partially overcome these limitations. Unfortunately, only 3/20 studies were RCTs, and even if all 3 focused on patients with SAH, they again were not totally comparable because of the different timing of assessments and the different neuropsychological tests used.[34,41,42]

We consider it reasonable, as some authors have suggested, to pre-alert surgical patients that total cognitive recovery can be delayed, on the basis of the observations reported in the second cluster of studies.[45]

Because some cognitive deficits are associated with lesions of the frontal lobes, we find it interesting that aneurysms in the anterior circulation, specifically in the anterior communicating artery, were present in similar percentages between the 2 clusters.[3,28,30,37,38]

The third cluster (Online Supplemental Data Table S2c) includes 15 studies analyzing groups of patients undergoing various INR treatments. Most of them (9/15) studied patients with RIAs or ischemic stroke, in whom the same acute events strongly influence the results. Indeed, neuropsychological sequelae after INR procedures are difficult to disentangle from the ones caused by the pathology itself, particularly when preoperative assessment is absent. Thus, we believe it is important to broaden knowledge about elective procedures, in which underlying conditions and other confounding factors can be better analyzed than in an emergency context.

The situation described above, calls for future investigations with larger samples and longer follow-up, including patients implanted with more recent devices, such as flow divertors.

The fourth cluster (Online Supplemental Data Table S2d) demonstrates that stent placement of the cervical segment of the ICA may offer more than just a reduced risk of stroke, contributing to improved cognition measured with the Mini-Mental State Examination, particularly in patients with highly impaired cerebral perfusion.[12,68] The clinical advantage was specifically detected in the verbal memory,[55] attention, and psychomotor processing speed,[65] more often in younger patients with the worst cognitive performance before the procedure.[70]

This last cluster, compared with the other ones, is less prone to bias and misinterpretation. In fact, the studies were mostly prospective, focused on the same pathology (vessel stenosis), with baseline cognitive function assessment frequently available.

In our research, globally, we found very few articles (8/65) that explored a possible relationship between neuroimaging and cognitive and/or psychological factors in patients undergoing neurointerventional procedures. The results reported are limited by various factors, including the restricted number of patients, the uneven CBV pathologies, and the different techniques used (MR imaging, PWI, DWI, and fMRI). Also in this area, further studies are needed to better understand the correlation among neuroimaging, neuropsychology, and cerebrovascular treatments.

The Online Supplemental Data Table S3 summarizes a list of points that we believe should be further investigated regarding psychological and cognitive variables of cerebrovascular patients undergoing INR procedures.

Limitations

The first limitation of this review is the poor standardization of the measurement of cognitive and psychological factors, which makes it difficult to compare data among studies. Additionally, the poor collection of data on psychiatric history limits the interpretations of results.

A second limitation is the strong influence of pathologic events and their related stress on the psychological and cognitive outcomes as well as the effect of the treatment procedure such as in the case of SAH or vasospasm in patients with RIA.

A third intrinsic limitation of our review is the inhomogeneity of the samples in terms of pathology and treatment.

However, our goal was not to investigate the cognitive and psychological factors of a single pathology or treatment but to consider these aspects in the everyday practice of interventional neuroradiology, raising awareness on the complexity of this crucial topic. Ideally, one should consider psychological and cognitive variables together, due to their mutual conditioning, without excluding psychophysiologic aspects such as fatigue and sleep.[6]

Finally, the research criteria may have limited this review because they may have excluded some articles dealing with similar topics.

CONCLUSIONS

Despite the numerous limitations that emerged from the analysis of the literature, our review highlights some important aspects regarding psychological and cognitive factors in INR.

The first message is that early psychological consultations[6,11,21] and behavioral interventions[7,23-26] can impact the management of anxiety and depression in subjects undergoing diagnostic or therapeutic procedures.[10] Even if treatment for anxiety and depression does not address functional deficits, it does contribute to improved QoL (Online Supplemental Data Table S1).[76] Possible differences in the cognitive outcome of patients undergoing EC versus SC remain debatable (Online Supplemental Data Table S2a-b), first and second clusters). In patients with RIA, without a preoperative assessment, it is almost impossible to distinguish damage caused by the disease from damage due to the treatment.[47,49] This limitation is overcome when preoperative testing is feasible, such as in patients with UIA, in whom endovascular treatment demonstrates no impact on cognitive functioning (Online Supplemental Data Table S2c, 3rd cluster).[51,54] Finally, all studies on the cognitive outcome of patients undergoing carotid stent placement agree in demonstrating cognitive improvement after the procedure, mainly due to a better redistribution of cerebral perfusion (Online Supplemental Data Table S2d, fourth cluster).

In accordance with other authors, we strongly believe that a better understanding of the relationship between the curative approach and the patient's cognitive and psychosocial profile could optimize the care of patients affected by cerebrovascular diseases.[49] Thus, a greater awareness of the importance of this relationship is needed to encourage its investigation in INR research and its integration into INR standard treatment protocols. To proceed, however, it is essential to identify a minimum set of neuropsychological and psychological tests, specifically designed for patients undergoing INR procedures, as recently implemented for the neurosurgical setting.[79] This identification would make the data shareable and comparable even independent of pathologies and treatments, overcoming the many limitations that we have encountered when reviewing the specific literature (Online Supplemental Data Table S3).

Finally, to our knowledge, this is the first comprehensive review considering all cognitive and psychological aspects in all types of INR procedures, diagnostic and therapeutic.

Disclosure forms provided by the authors are available with the full text and PDF of this article at www.ajnr.org.

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