Complications of Cerebral Angiography Performed at a University Hospital

Complicações de Angiografia Cerebral Realizadas em um Hospital Universitário

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ABSTRACT

Objective: The risk of complication of cerebral angiography has always been the focus of attention. The aim of this study was to evaluate the outcome of cerebral angiography performed in the first 30 months of operational training in the endovascular neurosurgery service of a university hospital. Methods: A retrospective study evaluated 129 digital cerebral angiography examinations in 91 patients at a university hospital from Southern Brazil. Results: The rate of complication was 2/129 (1.55%); of them, one (0.77%) presented a transient complication (hematoma puncture), and one (0.77%) a permanent complication with death of the patient because of an association between clotting in the middle cerebral artery and complications from the initial trauma. Conclusion: The rate of cerebral angiography complication obtained was low (1.75%) and underscores its reduced risk when performed in a neurological service even with professionals in training.

Key words: Cerebral angiography; Neurosurgery; Training; Subarachnoid hemorrhage.

RESUMO

Objetivos: O risco de complicação de angiografia cerebral tem sido constantemente foco de atenção. O objetivo deste estudo foi avaliar o resultado de angiografia cerebral realizada nos primeiros 30 meses de treinamento operacional em um serviço de neurocirurgia endovascular em um hospital universitário. Métodos: Foi realizado um estudo retrospectivo para avaliação de 129 resultados de angiografia cerebral digital realizada em 91 pacientes em um hospital universitário da região sul do Brasil. Resultados: A taxa de complicação foi de 2/129 (1,55%); destas, um (0,77%) paciente apresentou complicação transitória (hematoma no local da punção), e outro (0,77%) apresentou uma complicação permanente com óbito devido à associação entre coagulação na artéria média cerebral e complicações do trauma inicial. Conclusão: A taxa de complicação da angiografia cerebral observada neste estudo foi baixa (1,75%) e reafirma seu risco reduzido quando realizada em um serviço de neurocirurgia mesmo com profissionais médicos em treinamento.

Palavras-chave: Angiografia cerebral; Neurocirurgia; Capacitação; Hemorragia subaracnóide

INTRODUCTION

Despite the constant development of noninvasive techniques when acquiring vascular imaging, the cerebral angiography catheter is still the method of choice to the diagnosis of the majority of circulatory diseases of the head and neck and the digital angiography is still considered gold standard in the investigation of neurovascular diseases.

The potential morbidity and mortality and the high risks that are involved in cerebral angiograms indicate preference for less complex and aggressive diagnostics. Moniz (1927) is considered the creator of the method and who had described the use of angiography in the diagnosis of brain tumors. In the 1950’s, it was described the arterial catheterization technique that is still frequently used today. In 1991, the NASCET used cerebral angiography as their gold standard in studies of ischemic pathologies and indicated this method as a definitive
procedure. Further, it was described the sequence of the basic procedures to be followed in order to performed a cerebral angiogram safely6,7.

It was found that the vast majority of known centers of excellence and published clinical trials have been used angiography as their standard procedure when the treatment was decided. A great number of previous studies recommend cerebral angiography as their gold standard for investigation of bleeding disorders of the brain, regardless of other noninvasive imaging3-12.

The criteria for the indication and risk assessment of cerebral angiography, monitoring and rigorous supervision and enforcement of invasive examinations should be introduced into teaching hospitals, where the same complication rates are compared to other centers of excellence for neurovascular diseases treatment. Theoretical knowledge, vocational training and technical expertise are essential for the safety of this procedure; in this way, the learning of endovascular techniques requires close monitoring and constant evaluation of results, so as to minimize any additional risk to the patient. There is a consensus that the expertise of the physician is one of the determining factors for the success of this procedure. However, it is important to determine the hemodynamic safety index and the neurological procedures performed by the physicians that are in training, in specialized centers, even when under effective supervision.

The neurologic complication rate has been reported to increase with patient age13-16. Other risk factors have been reported such as long procedural time (length of the procedure), volume of contrast material, carotid stenosis, and ischemic stroke2,13,14,16.

In addition to patient risk factor, the operator experience has been evaluated as a risk factor for complication of cerebral angiography. Minimum training will be insisted on for conducting tests by professionals in training will always motivate discussion. Even though it seems obvious that strict training and the expertise of professionals may influence the possibility of complications of the angiography. The complication rate of cerebral angiography has been reported to be lower when performed by more experienced angiographers. Higher rate of neurologic complications were obtained in training hospitals (3.9%) compared with that in nontraining hospitals (0.9%) and general radiologist or angiographers had more than double the neurological complication rate (1.8%) compared with that of fully trained neuroradiologists (0.7%)15,16. Given the fact that angiography has risk and this occurrence is multifactorial, several cases have been sought to establish which variables are involved and that should be prevented in order to improve the results.

Taken together, the question to be answered is whether cerebral angiograms performed by doctors in training in the teaching hospital from Southern Brazil show lower rates of complications than those reported in literature. Therefore, the objectives of this study were to evaluate the outcome of cerebral angiography performed in the first 30 months of operation of the service training in neurosurgery at a university hospital, and to compare the results obtained with other studies carried out worldwide.

**Material and Methods**

This is a retrospective study of the medical records obtained from 91 patients that were examined by 129 digital cerebral angiography performed at the endovascular neurosurgery service of an university hospital of Southern Brazilian region from January 2006 to August 2008. It was included all patients of both gender regardless of age. The period of hospitalization and outpatient services at the institution was considered for analysis.

All patients signed an informed consent form approved by the Ethics Committee on Human Research at the State University of Londrina. All procedures were performed in the hemodynamics unit of the university hospital by a physician in the fourth year of residency in neurosurgery under the direct supervision of the professional responsible and neurosurgeons with specific training in diagnosis and endovascular therapy. The equipment for angiography monoplane (Axiomartis™, Siemens) and the contrast medium Iopamiron 300 (Bayer Schering Pharma) were used in the procedure. Femoral arterial punctures were performed following the technique previously described4. The local anesthesia was performed by lidocaine 10 mL 20 mg/dL (Cristalia™), and after the installation of the introducer was injected intra-arterial sodium heparine 1 mL 5,000 IU/mL (Liquemine™, Roche). Of the four procedures, two were made in children and two were in adults. In cases that patient consent or from consenting relatives was not
possible, necessary anesthesia sedation was given without any complications. The sheath introducers and catheters (5 French Judkins right), and hydrophilic guides of 3.5 French were used. In the protocols of cerebral angiographic studies, exams were routinely taken to check two carotid arteries and at least one of the vertebral arteries. In the study of the second vertebra it showed the possible absence of vertebral dysplasia and its importance in the diagnostic conclusion. There was an indication to study the aortic arch with a Pigtail 5 French catheter and a contrast injection pump only if suspect to the area.

The complications of the procedures were evaluated and organized according to the type, such as stroke, TIA, transient blindness, arterial damage at the puncture site, reaction to contrast, and the duration whether transient (< 24 hours) or permanent (> 7 days). The data obtained were entered into a database using Microsoft Office Excel 2007 Program for further analysis. An additional search of literature was done via MEDLINE, using cerebral angiograms terms, training from teaching hospitals, results and complications in Portuguese and English languages. No time limit was imposed for publication.

**RESULTS**

It was included the results obtained in 129 digital cerebral angiographs carried out on 91 patients, 59 female (64.83%) and 32 male (35.16%) in the period from January 2006 to August 2008, in the hemodynamics unit of the HU/UEL. The age of the patients varied from 3 to 77 years old (mean 46.86 ± 15.41 years old and median of 48.50 years old).

The clinical indications that motivated the need for the invasive vascular studies are shown in Table 1. In 24 (18.60%) cases, no abnormalities were verified in the findings of the conclusive angiographic results. In four procedures (3.10%) anesthesia support was necessary for two children, one disturbed adult and one adult with complications. There was one local transitory complication (0.77%), hematoma in the location of the puncture, quickly evaluated by the team of vascular surgeons and without any significant clinical repercussions. In one patient (0.77%) that had been admitted to hospital with severe traumatic brain injury caused by a traffic accident, the acute subarachnoid hemorrhage (SAH) was diagnosed by a computer tomography scan but there was clinical suspicion of rupture or stroke, indicating a need for digital cerebral angiograph to investigate the cause of SAH.

At the beginning of the study a saccular aneurysm was found in the anterior connecting artery and an important vasospasm angiograph of the anterior cerebral arterial areas (in particular A1 left and A2 bilateral) and left middle cerebral artery was noticed. In the first set of angiographs, in the right middle cerebral artery a thrombus was found obstructing the bifurcation of this vessel. Faced with this complication, it was made the change from local anesthesia to general and immediate mechanical thrombectomy. Immediately a satisfactory flow was established in the occluded vessel. The patient died seven days after due to an association of complications from the initial trauma, vasospasm and cerebral ischemia.

<table>
<thead>
<tr>
<th>Primary indications of tests</th>
<th>Number of tests</th>
<th>Percentage (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Acute subarachnoid hemorrhage</td>
<td>39</td>
<td>30.23</td>
</tr>
<tr>
<td>Control after embolization of aneurysm</td>
<td>25</td>
<td>19.38</td>
</tr>
<tr>
<td>Investigation of unruptured aneurysm</td>
<td>20</td>
<td>15.50</td>
</tr>
<tr>
<td>Control after aneurysm clipping</td>
<td>16</td>
<td>12.40</td>
</tr>
<tr>
<td>Arteriovenous malformation</td>
<td>10</td>
<td>7.75</td>
</tr>
<tr>
<td>Ischemic stroke</td>
<td>05</td>
<td>3.87</td>
</tr>
<tr>
<td>Control post-embolization</td>
<td>04</td>
<td>3.10</td>
</tr>
<tr>
<td>Arteriovenous fistula</td>
<td>03</td>
<td>2.33</td>
</tr>
<tr>
<td>Tumor</td>
<td>03</td>
<td>2.33</td>
</tr>
<tr>
<td>Cranial injury</td>
<td>02</td>
<td>1.55</td>
</tr>
<tr>
<td>Venous sinus thrombosis</td>
<td>02</td>
<td>1.55</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>129</strong></td>
<td><strong>100.00</strong></td>
</tr>
</tbody>
</table>
The present study reports the first results of the implementation of a neuroendovascular diagnosis and therapeutic procedures unit in neurosurgery service of Southern Brazilian university hospital, where until then the patients were evaluated by other health services professionals. In most of the cases evaluated (77.5%), the angiographic studies were referred for investigation or control after treatment of brain aneurysms, and in only 3.87% of the cases were related to ischemic disease. Among the evaluations, there was one local transitory complication (0.77%) revealed by hematoma in the location of the puncture without any significant clinical repercussions.

Since the discovery of the angiography as an important diagnostic tool, almost indispensable in the past, and its acceptance into the scientific community, the invasive nature and its consequent risk of complications has always been the focus of attention in research that tries to measure the possibility of complications.

Among the etiologic factors of complications of diagnostic angiography, a key factor appears to be referring to the experience of the professional and/or the team that are performing the procedure. Experienced professionals should have complication rates below 1.0%. The lowest complication rates are obtained in centers where these procedures are performed only by experienced professionals. This conclusion, although it seems obvious, does not agree with previous studies\(^\text{2, 14, 17}\) that found ischemic vascular disease as the main factor complicating cerebral angiograms. Other study\(^\text{18}\) suggests that the complication rates remains unchanged despite the developments of the method and training of surgeons.

Previous studies\(^\text{14, 19, 20, 21}\) also found no difference in the complication rate and the level of training. Some studies\(^\text{21-25}\) suggested protocols for training and evaluation of those who are proposing to carry out research and studies of the treatment of the endovascular of the CNS. These authors acknowledged that cognitive and appropriate technical training, together with appropriate expertise and experience, are essential to perform these procedures that offer significant risk to the health of the patient. This principle guides medical education, but must be followed particularly in the context where a stroke may be a consequence of the procedure.

There are several proposed minimum training requirements for qualification in endovascular procedures. In 2005, it was published a joint statement along with standards of training, competency and qualifications for cervicocerebrais angiograms, and recommends that a minimum of 100 diagnostic coronary angiographic procedures must be done, before starting any training in endovascular therapy\(^\text{22}\).

Analysis of learning curves suggests that a minimum of 200 diagnostic angiograms must be done to be considered a qualified examiner. The effect of training and experience was clearly shown in a study of 5,000 angiograms where experts from specific training programs in neuroradiology had 0.5% of neurological complications rate, lower than 0.6% from professionals considered experienced but without formal training, and than 2.8% from those professionals who were still in training. With the advances in noninvasive techniques for diagnosis, the interest in the course of diagnostic angiography has been decreased, especially for evaluation of carotid atheromatous disease; however, this decrease was partially compensated by an increase in angiographic studies to clarify anomalies or suspicious findings revealed by tomography or vascular magnetic resonance.

The chance of any complication with a cerebral angiography is small. However, it is important to be aware of the possible risks, which include internal bleeding, damage to a blood vessel, infection, allergic reaction to the contrast dye, and stroke. Cerebral angiography was associated with a total risk of 1.0% for neurological loss and 0.5% for permanent deficiency\(^\text{14}\). However, all losses represent a worsening of pre-existing conditions. All complications occurred in patients with a history of cerebrovascular accident, TIA or carotid murmur, which reflects the difficulty in performing angiographic studies in these patients.

The risk of permanent neurological loss as a result of diagnostic angiography is considerable and ranges from 0.1 to 5.7% in the literature. Moreover, there still exists an additional risk of temporary loss which ranges from 0.3 to 6.8%. One study\(^\text{3}\) suggests that the type of the risk varies with nature of the investigated pathology, age, comorbidities, procedure technique difficulties, and the experience of the team.

A significant increase in the incidence of neurological events from zero to 24 hours after the examination when the procedure lasted more than 60 minutes and when arterial hypertension
was reported\textsuperscript{13}. In addition to duration of procedure and the presence of hypertension, other factors are associated with risk of complication such as the volume of contrast material, patient age, diabetes\textsuperscript{13}, elevated levels of creatinine, and the number of catheters used\textsuperscript{14}.

In a meta-analysis, the neurologic complication rate was lower in patients with a subarachnoid hemorrhage, aneurysm, or arteriovenous malformation compared with that in patients with ischemic stroke\textsuperscript{2}.

The type of disease studied always seemed to be associated with the risk of the procedure. Cases reports showed that ischemic cerebral angiography events were secondary and worse than the ischemic phenomena preexisting in twice as many cases as new cases\textsuperscript{13}.

A prospective study\textsuperscript{17} was carried out to evaluate the occurrence of silent embolism in patients undergoing cerebral angiography with further investigation using an MRI of the brain, where approximately a quarter of the patients studied showed ischemic injury even though they were clinically asymptomatic.

The profile of patients and the most prevalent diseases may influence the results of this diagnostic procedure. In the pediatric population, the risk seems to be lower than in adults. In a study\textsuperscript{1} that evaluated 241 children who underwent to angiography, any complication was not observed, and this result was directly accredited to the procedure described. A meta-analysis\textsuperscript{2} evaluated the results obtained in angiographic studies carried out in patients with suspected of SAH and patients with ischemic diseases. In those patients with SAH the complication rate was significantly lower than ischemic diseases (1.8\% versus 3.7\%, \(p=0.03\)). When comparing patients who had a diagnosis of aneurysm or arteriovenous malformation, without SAH, with ischemic illness the difference is even greater (0.3\% versus 3.7\%, \(p=0.001\)).

Considering that the lowest risk found for a complication that results in permanent neurological lesion in the population in general is 0.1\%\textsuperscript{24}, the presence of a previous disease such as an asymptomatic carotid artery stenosis, the rate of complication could reach 1.2\% in some series\textsuperscript{14,16,23}.

In the most recognized study carried out in the United States of America that evaluated the benefits of carotid endarterectomy in symptomatic patients with high rate of carotid stenosis\textsuperscript{2}, the percentage of stroke due to angiography in more than 2,200 patients studied was approximately 0.7\%. According to a previous study\textsuperscript{2}, a patient with symptomatic carotid stenosis has an increase of ten times of the risk of an ischemic occurrence than by an asymptomatic angiography. Other study\textsuperscript{17} showed that 25.0\% of patients who underwent diagnostic angiography showed signs of ischemia, which were clinically silent, detected only in the resonance of the cranium. The presence of diseases related to atherosclerosis and ischemic disease contributes directly to the increase of complications, even more important than the technical quality and team expertise or the evolution of equipment and materials used (digital angiography, contrast media, catheters and guides). A prospective study\textsuperscript{14} evaluating 1,000 cerebral angiograms found 1.0\% of complications; of them, 0.5\% was of permanent nature and, in all these cases, there was a history of stroke, TIA or carotid murmur, reflecting the difficulty of studying this population in particular.

One study\textsuperscript{16} suggested that advances in cerebral angiography did not decrease the risk of complications in patients and the results showed that the risk of neurological complications increases a relative 2.2\% for each 10-year increase in age, and a significantly higher rate was found in patients with 55 years of age or older. Even though patients outside of the age group are at risk, the real need for invasive studies should still be considered. Other study\textsuperscript{1} did not describe any significant complication directly related to the procedures and the authors suggested that, even though the risk exists, it is low in children.

Despite the limited number of patients that were evaluated in the present study, it was observed that the rate of complications is in agreement to other series described in the literature. The characteristics of samples showed that in the majority of cases, it was an association to vascular hemorrhage and not with the ischemic event which could have influenced the results obtained, minimizing other risk factors such as the training of the professionals.
CONCLUSION

This study reports the occurrence of one (0.77%) transient local complication (hematoma puncture) with no clinical repercussion, and 1 (0.77%) permanent complication, a distal embolism which contributed to a fatal outcome in a patient initially hospitalized for traumatic brain injury (TBI) with subsequent diagnosis of SAH vasospasm and ruptured aneurysm. All angiographic studies had the effective participation of doctors in training. Comparing to the previous reports in literature, the results obtained in the present study can be evaluated as the first step to create the service according to the desired standards of safety that are found in the majority of treatment centers for vascular disease. In this way, insisting on adequate training, respecting the accuracy of universally recognized technology for neuroendovascular procedures (diagnostic or therapeutic) and faced with results obtained in the literature, it is expected that the present results can contribute to the improvement of the endovascular neurosurgery service of the university hospital from Southern Brazilian region identifying and offering grounding for the prevention and reduction of the complications inherent in the method. Similar studies evaluating a great number of samples in a university hospital could corroborate the results obtained in the present study.

REFERENCES


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