Karen Raymer MD FRCPC,
Peter Choi MD

Concurrent subarachnoid haemorrhage and myocardial injury

Purpose: Subarachnoid haemorrhage is frequently associated with myocardial injury and dysfunction. This report describes such a case, reviews the understanding of this phenomenon, and discusses the implications for timing of surgical clipping of intracranial aneurysm in patients with concurrent myocardial damage.

Clinical Features: A 64-yr-old woman presented with syncope and congestive heart failure. A diagnosis of subarachnoid haemorrhage was made three days following the initial diagnosis of myocardial infarction. The patient presented for clipping of an intracranial aneurysm on day 36, after her cardiac status had stabilized. No new myocardial ischaemic events occurred, either intra-operatively or post-operatively. Ultimate neurological recovery was poor.

Conclusions: This case report demonstrates four important aspects of the clinical course of patients with concurrent subarachnoid haemorrhage and myocardial damage: 1) On presentation, cardiac features may predominate, and delay diagnosis and treatment of the underlying subarachnoid haemorrhage. 2) Left ventricular dysfunction, although dramatic, is usually transient. 3) There is confusion regarding the appropriate cardiac risk assessment and management in such patients when presenting for surgery. 4) Long-term morbidity is most often related to neurological, not medical, complications.

Objectif : L'hémorragie sous-arachnoïdienne s'accompagne souvent d'une lésion et d'un dysfonctionnement myocardiques. Ce compte rendu décrit un cas de cette affection, fait un survol de nos connaissances et discute de l'importance de bien planifier le moment de clamer l'anévrisme intracrânien chez des patients atteints d'une lésion myocardique.

Éléments cliniques : Une femme de 64 ans se présente en état de syncope et d'insuffisance cardiaque. On constate qu'elle présente une hémorragie sous-arachnoïdienne trois jours après le diagnostic initial d'infarctus du myocarde. Trente-six jours plus tard, après stabilisation de la condition cardiaque, on insère un clip sur un col anévrysmal. Elle ne présente pas de nouveaux épisodes d'ischémie myocardique peropératoires et postopératoires. La récupération neurologique définitive a été médiocre.

Conclusions : Cette observation illustre quatre aspects importants de l'évolution clinique de patients victimes d'hémorragie sous-arachnoïdienne et de lésion myocardique simultanées: 1) au départ, les éléments cardiaques peuvent prédominer et retarder le diagnostic et le traitement de l'hémorragie sous-arachnoïdienne sous-jacente. 2) L'insuffisance ventriculaire gauche tout en étant dramatique est transitoire. 3) L'évaluation du risque cardiaque et la prise en charge de ce type de patient pour la chirurgie prête à confusion. 4) la morbidité à long terme est plus souvent en rapport avec les complications neurologiques que cardiaques.

From The Department of Anaesthesia, Hamilton General Hospital, McMaster University, 237 Barton St. E., Hamilton, Ontario L8L 2X2.
Address correspondence to: Dr. Karen Raymer.
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MYOCARDIAL damage occurring in association with an intracerebral event is a well-described phenomenon.^{1,2} The myocardial damage is believed to result from an associated catecholamine surge.³⁻⁶ The degree of damage may be minor, evident only by elevation of cardiac enzymes,⁷ or major, causing haemodynamic instability and left ventricular (LV) failure.⁸⁻¹¹ In most cases, the myocardial injury is transient, showing clinical, echocardiographic and histological resolution within two weeks of the acute intracerebral event.^{12,13} Patients with recent myocardial infarction (MI) presenting for non-cardiac surgery are known to be at increased risk of peri-operative cardiac complications.¹⁴⁻¹⁶ The risk facing patients with a "central" cause of cardiac injury is not known. We present a case of a patient with concurrent subarachnoid haemorrhage (SAH) and MI, presenting for clipping of intracranial aneurysm.

Case report

A 64-yr-old, 60-kg Caucasian woman with a history of Canadian Cardiovascular Society Class I angina was witnessed to have a sudden loss of consciousness without prodromal symptoms. She was rushed to a community hospital and was found to have clinical and radiological evidence of pulmonary oedema as well as electrocardiographic (ECG) changes (ST depression in leads II, III, and aVF with reciprocal ST elevation in aVL and V2) suggestive of a subendocardial myocardial infarction (Figure 1). Serial creatinine kinase (CK) levels were not elevated but MB fractions were >5% on all three measurements. The patient was admitted to the coronary care unit, with a diagnosis of acute MI. The trachea was intubated, and the lungs were mechanically ventilated.

Over the next two days, the patient was weaned from the ventilator. However, she remained confused and disoriented. A computed tomographic scan of her head showed a right frontal intracranial haemorrhage. Her level of consciousness remained unchanged over the next three days and she was transferred to a tertiary care hospital for further neurosurgical management.

The patient was admitted to the intensive care unit (ICU). 2D-echocardiography revealed moderate tricuspid regurgitation, pulmonary arterial pressure (PAP) of 60 mmHg, and anteroseptal and apical left ventricular hypokinesis with an ejection fraction (LVEF) of 33%. Cerebral angiography showed an anterior communicating artery aneurysm. The patient was transferred to the neurosurgical ward six days later. She was placed on metoprolol and lisinopril. Although no clinical evidence of LV dysfunction remained, the medical consultant felt

FIGURE 1 ECG on admission, showing ST depression in leads II, III, and aVF, with reciprocal ST elevation in V2 and aVL.

that surgery should be delayed in order to minimize the risk of further cardiac complications.

On day 34, the opinion of a cardiologist was obtained. Repeat 2D-echocardiogram showed resolution of the LV dysfunction, with a LVEF of 58%. A persantine thallium scan was normal. Neurologically, she was cooperative, but remained disoriented, with poor memory, and left sided weakness. After anaesthesia consultation and discussion with the patient and her family, craniotomy and aneurysm clipping were undertaken 36 days post-MI.

Preoperatively, the patient received her regular medications, which included metoprolol and lisinopril. Routine monitors, including five lead ECG with continuous ST segment analysis were applied. A radial arterial line and pulmonary artery catheter were inserted. Anaesthesia was induced with 2 $\mu\text{g}\cdot\text{kg}^{-1}$ sufentanil, 10 mg vecuronium, and 4 mg midazolam. Anaesthesia was maintained with a balanced technique using 50% O_2 in air, isoflurane 0.4–1%, and intermittent boluses of sufentanil, pancuronium, and midazolam, as required. Intermittent boluses of labetalol and phenylephrine were used to maintain blood pressure at 120/50 (± 10) mmHg and heart rate at 60 (± 10) beats per minute. Throughout the case vital signs remained stable. Total anaesthetic time was six hours and 50 min. The neurosurgical course was uncomplicated and the patient was transferred to the ICU, sedated, and the lungs were mechanically ventilated.

The patient remained stable in the ICU. No new neurological deficit developed and there were no myocardial ischaemic events. The trachea was extubated on the second post-operative day and the patient was transferred two days later to the neurosurgical ward. Unfortunately, her cognitive function remained

impaired. She was transferred to a long-term care facility three weeks after surgery.

Discussion

This report describes a patient who sustained cardiac injury after SAH. Her LV dysfunction was dramatic, and delayed both diagnosis and treatment of the intracranial aneurysm. Intra-operatively, attempts to minimize cardiac risk were made. These included the use of a pulmonary artery catheter, the avoidance of myocardial depressant anaesthetic agents, and the maintenance of optimal myocardial supply and demand. Post-operatively, her cardiac status remained stable, however her ultimate neurological recovery was poor.

Most physicians are aware that ECG changes commonly occur in patients with cerebral lesions. This phenomenon occurs in 50–90% of patients with acute intracerebral events.^{5,6,17} Several ECG abnormalities associated with SAH have been described.^{6,9–12,17} While deep T wave inversion is the most typical change, most patients demonstrate only non-specific ST changes.

Less well known is the fact that the ECG changes are frequently associated with myocardial damage.^{7–13,17–23} Numerous reports of elevated CK-MB concentrations in the plasma of patients with SAH support the notion that cardiac necrosis occurs.^{7,8,10–12,18,20} In fact, echocardiographic studies have found wall motion abnormalities in 9–23% of patients with SAH and ECG abnormalities (with no previous history of cardiovascular disease).^{9–11} The presence of wall motion abnormalities is best predicted by T wave inversion¹⁰ and prolonged QT^{10,11} interval. While ECG changes are a relatively non-specific marker for the presence of myocardial dysfunction in patients with SAH, they are remarkably sensitive: no patient with a normal ECG demonstrated any clinical or echocardiographic evidence of LV dysfunction.^{9–12}

Where myocardial damage is present, its progression seems to follow a predictable course, both clinically and pathologically. A large prospective multicentre trial showed that the majority of patients who developed pulmonary oedema did so in the first week after SAH.²¹ In the vast majority of patients, myocardial damage is transient, with subsequent echocardiograms showing resolution of LV dysfunction within 14 days.^{7,12,20} An autopsy study examined the hearts of 58 patients who died of acute intracerebral lesions.¹³ Multifocal, transmural damage (TMD) was common, occurring in 36 patients. No evidence of TMD was found in any patient who died more than two weeks after the acute intracerebral event, corresponding to the transient nature of the LV dysfunction seen in survivors.

The common factor producing depolarization changes, myocardial dysfunction, and TMD in association with an acute intracerebral event is an increased plasma catecholamine concentration.^{2–6} A sudden increase in intracranial pressure (ICP) stimulates cortical and subcortical areas of the brain, leading to autonomic instability.^{24,25} In experimental models, catecholamine infusions produce cardiac lesions which are histologically similar to those seen in the above-described autopsy study.²⁶ Furthermore, in both experimental and clinical intracerebral haemorrhage, cardiac damage is prevented by beta-adrenergic blockade.^{27–29}

The severity of the neurological insult (and therefore, the magnitude and duration of the catecholamine surge) may determine whether a patient develops myocardial damage. For example, in patients with SAH, poor neurological grade was associated with the presence of wall motion abnormalities.^{9–11} At autopsy, the presence of TMD was related to the size of the intracerebral lesion.¹³

The distribution of myocardial injury occurring in association with an acute rise in ICP is multifocal, and unrelated to coronary vascular distribution.^{13,20–23} This is consistent with the pattern of cardiac necrosis induced by exogenous catecholamine infusions (in experimental models)²⁶ and by elevated endogenous catecholamines (in pheochromocytoma).³⁰ These findings imply that the catecholamine surge is not simply causing coronary vasoconstriction. A direct calcium-mediated injury, known as contraction band necrosis, results from exposure of the myocardium to high plasma catecholamine levels.^{20,25} However, evidence suggests that a more complex supply-demand mismatch is induced. For example, smaller (<2 cm) intracerebral lesions were found to induce TMD only when they occurred in association with systemic shock.¹³

Regarding the management of a patient with concurrent subarachnoid haemorrhage and myocardial damage, two issues arise. First, if such a patient presents for early clipping of the intracranial aneurysm, the risk of post-operative cardiac complications needs to be assessed. Second, given the competing risks of aneurysmal rebleeding and cardiac complications, the optimal timing of surgical clipping of the intracranial aneurysm must be determined.

Despite the wealth of literature evaluating cardiac risk in patients presenting for non-cardiac surgery, only two risk factors have been consistently identified: recent MI and current congestive heart failure (CHF).³¹ While both may be present in the patient with SAH, it is unclear whether the existing data can be

applied to this subgroup of patients with a "central" cause of myocardial damage and dysfunction.

Delaying aneurysmal clipping, until resolution of LV dysfunction has been demonstrated, carries its own risk: in untreated aneurysms, the risk of rebleeding is highest over the first week, (11%), after which the risk decreases, reaching a plateau at four weeks.³² Rebleeding is fatal in 50–78% of patients, and is associated with considerable neurological morbidity in survivors.³³ Furthermore, the aggressive treatment of vasospasm, which may appear as early as 10 days after the acute event, poses a greater risk in the patient whose aneurysm remains unclipped. Solenski²¹ studied 457 patients with SAH, with early surgical management occurring in over 2/3 of cases. After three months, medical complications accounted for less than half the number of deaths that were caused by rebleeding and vasospasm. Morbidity is even more strongly related to neurological complications.

Timing of surgery was addressed in Clinical Decision Making in 1987.³² McNutt and Pauker described the case of an 87-yr-old woman who presented with a subarachnoid haemorrhage. She was scheduled for clipping of an intracranial aneurysm, to be carried out on day 5. However, on day 4, she suffered a subendocardial myocardial infarction. Analysis of the competing risks for this particular patient was carried out. The authors concluded that the risk-benefit analysis favoured operating in the first week after rupture. After this, the diminished potential benefits of reducing neurological morbidity and mortality were outweighed by the risk of cardiac morbidity and mortality, which would decrease more slowly, and remain relatively high, for the six month period.

In conclusion, when SAH leads to myocardial injury, the cardiac features may be so prominent that the primary neurological diagnosis is delayed. While LV dysfunction is usually transient, its presence may delay definitive management of the aneurysm. In the case presented, delay in surgical management exposed the patient to increased risk of neurological morbidity, with uncertain cardioprotective benefits. To perform a meaningful risk-benefit analysis, better understanding of the perioperative cardiac morbidity and mortality in this particular group of patients is required.

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