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Early Neurological Abnormalities Following Coronary Artery Bypass Surgery

A Prospective Study

H. Strenge[1], V. Lindner[1], G. Paulsen[2], D. Regensburger[3], and S. Tiemann[3]

[1]Department of Neurology and [2]Department of Psychiatry, University of Kiel, Niemannsweg 147, D-2300 Kiel, Federal Republic of Germany
[3]Department of Cardiovascular Surgery, University of Kiel, Arnold-Heller-Strasse 7, D-2300 Kiel, Federal Republic of Germany

Summary. A prospective analysis of 78 patients undergoing coronary artery bypass surgery (CABS) was carried out to assess clinically the frequency and course of cerebral complications during the 1st postoperative week. Detailed evaluation of the patients showed that neurological abnormalities after CABS were common, occurring in 40 of the 78 patients (51%). However, there were no serious cerebral complications. Changes in reflexes and new focal signs were found in 26 and 25 cases respectively; in 7 patients (9%) they were confined to the first postoperative days. There was no statistically significant correlation between postoperative outcome and age, preoperative neurological state or bypass time. However, some strong associations could be calculated between a history of cerebrovascular signs or symptoms and the appearance of persisting focal signs or development reflexes during the 1st week after CABS.

Key words: Cerebral complication – Clinical course – Coronary artery bypass surgery

Introduction

There has been a rapid growth of interest during the past few years in neurological complications after open-heart surgery (Javid et al. 1969; Tufo et al. 1970; Branthwaite 1972, 1973; Meyendorf 1976; Mohr 1979; Coffey et al. 1983; Sotaniemi 1983; Sotaniemi et al. 1986; Aberg 1988). Despite continuing improvements in operative, anaesthetic, and perfusion techniques, brain injury continues to occur in cardiac surgery with a higher incidence than in any other non-cerebral operation (Bashein 1988).

So far, few prospective extensive studies have been devoted to the general survey of all neurological abnormalities following coronary artery bypass surgery (CABS) (Götze and Dahme 1980; Breuer et al. 1983; Shaw et al. 1985; Smith et al. 1986; Carella et al. 1988). Moreover, even in these publications detailed information about the clinical course of neurological disturbances in the early postoperative phase is not available.

Hence, it was the aim of this investigation to define the incidence and severity as well as the dynamics of new clinical abnormalities in the early stage after CABS and to analyse possible connections with pre- and intraoperative parameters.

Subjects and Methods

We studied the cases of 78 consecutive patients undergoing CABS at the Department of Cardiovascular Surgery of the University of Kiel between May 1987 and October 1988. The study group included 61 males and 17 females, with an age range of 39–74 years (mean 59.5, SD 8.2).

Using the New York Heart Association (NYHA) functional classification, all patients were class III. Previous myocardial infarction had occurred in 65%; 44% had a history of hypertension and 19% had a history of cigarette smoking. The incidence of diabetes mellitus was 18%; hyperlipidaemia was found in 35%. Preoperative Doppler ultrasonographic examinations revealed bilateral stenosis of the internal carotid artery in one patient of our sample; this finding was additionally confirmed by intravenous digital subtraction angiography (DSA).

Anaesthesia and surgery were standardized. Non-pulsatile extracorporeal perfusion was performed with a Bentley bubble oxygenator in 45 patients and with a membrane oxygenator in 33 cases. An arterial line filter (40 μm) was routinely included

Offprint requests to: H. Strenge

in the circuit. Extracorporeal flow was maintained at 2.5 l/m^2 per minute at a perfusion pressure of 60–70 mm Hg. A Stöckert roller pump was used. Haemodilution was total and a haematocrit ranging between 26 and 32% was accepted. Cardiopulmonary bypass was maintained with moderate hypothermia (rectal temperature between 27 and 32°C); lower temperatures were used with cold cardioplegia (4°C). The median values of the bypass time and the aortic cross-clamping time were 80 min (range 39–140) and 39 min (range 20–112) respectively. The number of grafts ranged from 1 to 6 (median 3).

After informed consent had been obtained, each patient underwent a detailed neurological history and examination according to a standardized protocol 2–3 days prior to surgery. Repeat neurological examinations were done by the same investigator 2–3 days as well as 6–8 days after CABS. All disturbances including subtle clinical signs were recorded. The palmomental and snout reflexes were assessed according to the criteria of Tweedy et al. (1982), together with the extensor plantar response (Babinski's sign) they were labelled development reflexes in this study.

In some cases the proper performance of cerebellar function tests in the early phase after surgery was vitiated by the surveillance equipment and postoperative pain. Therefore, the ratings of past pointing tests were not included in this study of the immediate outcome.

In order to investigate the relationship between age, history, pre- and intraoperative findings and the postoperative state, a configural frequency analysis was performed (Lienert 1971; Von Eye 1988). The application of this method is based on the assumption that subjects are observed with respect to different characteristics with a vector of states named "configurations" or "types". For this kind of evaluation binary classifications of each variable were used, e.g. absence vs presence of signs; patterns of above vs below median values of quantitative data. Because of the limited sample size only triples of variables were considered at one time, for the detection of significant associations. To adjust for multiple comparisons the Bonferroni method was applied to the computed P values (initial critical value = 0.05, adjusted for $2^3 = 8$ comparisons).

Results

Thirty of the 78 patients (38%) had a previous history of vertigo, nausea, dizzy and/or fainting spells. Temporary hearing disorders, mostly tinnitus, and chronic headaches were reported by 18 patients (23%) each. In 14 cases (18%) there had been prior fleeting signs (hemiparesis, scotoma, diplopia, dysarthria) or strokes. In addition, 9 patients (12%) had histories of previous head injuries.

The preoperative neurological assessment revealed detectable abnormalities in 35 out of 78 cases (45%). Minor signs of peripheral nerve disorders (decreased deep tendon reflexes, sensory loss, paraesthesias, lower motor weakness) were found in 13 patients. However, in 28% of all cases (22 patients) the neurological signs were attributable to the central nervous system (CNS). Many disturbances could be related to the cortico-bulbar tracts or cranial nerve nuclei (the oculomotor, trigeminal, facial and hypoglossal nerves). In addition, isolated, mostly slight, unilateral hyper-reflexia, dysmetria, dysarthria, Babinski's sign and resting tremor were observed. In 10 cases, the patterns of abnormalities were compatible with circumscribed brain lesions affecting the brain stem (7 patients), the hemispheres (2 patients) and the spinal cord (1 patient).

After CABS 40 patients (51%) developed new clinical abnormalities due to CNS dysfunction at any time during the 1st postoperative week. New development reflexes and new focal signs were found in 26 (33%) and 25 (32%) cases respectively. In addition, 3 patients (4%) developed brachial plexopathy affecting the C8 and T1 roots.

Three patients died of cardiac disease but did not display any CNS signs in the examinations made according to the protocol. Severe disturbances, such as fatal cerebral hypoxic damage, definite strokes or haemorrhages did not occur in our study group.

A summary of the frequencies and dynamics of new postoperative signs at both examination times is given in Table 1. The highest rate of reversibility during the 1st postoperative week was found for Babinski's sign. In 5 of 9 patients this reflex had disappeared after 1 week. Both a unilateral hyper-reflexia and an abducens nerve dysfunction were totally reversible in 6 of the 15 cases concerned. On the other hand, the newly developed supranuclear facial pareses were constantly detectable 6–8 days after surgery in 6 of the 8 affected patients. In general, there seemed to be no clear-cut difference between the early clinical course of new focal signs and of new development reflexes.

After having analysed the distribution of clinical signs among different patients the manifestation of

Table 1. Frequencies and dynamics of new neurological signs following coronary artery bypass surgery (CABS) in 78 patients

Sign	Number of patients			
	Time of occurrence (postop.)			Total
	2–3 Days (post 1)	6–8 Days (post 2)	2–8 Days (post 1 + 2)	
Palmomental reflex	5	2	7	14
Snout reflex	2	5	4	11
Hyper-reflexia (unilateral)	4	4	2	10
Babinski's sign	5	2	2	9
Facial paresis (supranuclear)	1	1	6	8
Abducens paresis	2	2	1	5
Ptosis	1	1	1	3

Table 2. Clinical courses of neurological abnormalities after CABS

Clinical course during 1st post-operative week	Number of patients	Area of CNS dysfunction		
		Hemi-sphere	Brain stem	Uncer-tain
1. Complete recovery	8 (20%)	1	4	3
2. Incomplete recovery	5 (13%)	1	2	2
3. No change	12 (30%)	0	3	9
4. Progression and/or additional new signs	9 (22%)	2	5	2
5. Late signs	6 (15%)	1	2	3
Total number	40 (100%)	5	16	19

postoperative neurological findings was studied on an individual basis. An overview of all clinical courses of neurological disturbances during the 1st week after surgery is given in Table 2. There were 8 patients who developed fleeting signs only detectable 2 or 3 days after operation. There were another 5 patients with an incomplete recovery, 12 with no changes and 9 patients with progression of early postoperative abnormalities and/or occurrence of additional new signs (unilateral hyper-reflexia, Babinski's sign, scotoma). Six cases did not reveal neurological disturbances until the end of the 1st postoperative week. With respect to the individual combinations of signs we concluded that the brain stem was involved in 16 cases and the hemispheres in 5 cases (left-sided 4, right-sided 1). The exact anatomical site of dysfunction remained uncertain in 19 cases with isolated signs or primitive reflexes.

To analyse possible interdependencies between the neurological history, coronary risk factors and preoperative state, intraoperative variables and the immediate outcome, binary data of these parameters were subjected to a configural frequency analysis. Statistical associations between triples of variables were examined by comparing the observed number of patients exhibiting specific combinations of features with the number predicted from the overall incidence rates, assuming that the presence of one was independent of the others.

A multivariate approach with the strongest positive associations is shown in Table 3. A "type" consisting of 10 patients was found that showed the combination of a previous history of cardiovascular symptoms and new focal signs after surgery both at the first and second examination. A second subpopulation of 10 cases was characterized by an abnormal

Table 3. Configural frequency analysis: strongest positive associations between triples of clinical parameters in 78 CABS patients

Characteristics	Number of cases observed (predicted)	χ^2
I. History with signs and/or symptoms and new focal sign at 2–3 days post and focal sign at 6–8 days post	10 (3.22)	14.28*
II. History with signs and/or symptoms and new development reflex at 2–3 days post and development reflex at 6–8 days post	10 (3.28)	13.77*
III. New development reflex at 2–3 days post and development reflex at 6–8 days post and no new focal sign	11 (3.75)	14.02*

* $P < 0.001$ ($df = 1$)

history and new development reflexes constantly detectable until the end of the 1st postoperative week. There was a considerable overlap with a third configuration of 11 cases indicating a marked difference between patients developing new focal signs and those with new development reflexes following CABS.

Statistically reliable configurations which include the age of the patient, preoperative neurological disturbances, intraoperative features or a fluctuating course after surgery could not be found. However, a tendency of some kind of relationship was calculated for the combination of age below 61 years, normal history and no occurrence of development reflexes after surgery ($n = 10$; $\chi^2 = 4.20$). There was a rather weak association between the appearance of new focal signs and additional new development reflexes combined with an aortic clamp time above the median value of our distribution ($n = 7$; $\chi^2 = 3.84$).

Discussion

The present study confirmed the well-known incidence of neurological disturbances following CABS (39–64%: Götze and Dahme 1980; Breuer et al.

1983; Shaw et al. 1985; Smith et al. 1986; Carella et al. 1988). Fifty-four per cent of our patients developed new clinical abnormalities obviously related to perioperative brain injury. In addition, there was a relatively high proportion of patients (45%) showing clinically detectable neurological dysfunctions prior to surgery, underscoring the importance of a prospective approach in determining cerebral complications following CABS. Similar rates of preoperative findings (27–35%) were reported in previous studies (Götze and Dahme 1980; Breuer et al. 1983; Shaw et al. 1985).

In our population major neurological complications did not occur. Many patients with new clinical findings displayed one or two subtle focal signs often attributable to the motor system and sometimes accompanied by corresponding symptoms. However, approximately one-third of our patients exhibited new development reflexes only detectable by a systematic neurological examination. These findings are similar to those of Shaw et al. (1985) and Carella et al. (1988) who emphasized a significant increase of incidence rates of primitive reflexes following CABS.

Because of the paucity of signs in many individual cases of our study a classification into various syndromes of the carotid and vertebral-basilar arteries or small penetrating branches (Caplan 1980; Fisher 1982; Toole 1984) could not always be obtained with any certainty.

Previous investigations concerning the immediate outcome have focused on different degrees of disability and therefore contain some discrepancies as to the remission of neurological signs after CABS (Götze and Dahme 1980; Shaw et al. 1985; Smith et al. 1986). In our study different clinical courses during the 1st postoperative week could be observed which were not associated with a particular type of brain lesion or the preferential occurrence of either focal signs or development reflexes (cf. De Reuck et al. 1981).

Current hypotheses are that the mechanisms involved in the genesis of development reflexes are likely to be multiple (Nathan and Smith 1955; Van Gijn 1978; Maertens de Noordhout and Delwaide 1988). Therefore, they may only be taken as an unspecific indicator of cerebral dysfunction. Although the concept of "primitive reflexes" is extensively questionned (Landau 1989), we believe that the reappearance of these signs after CABS could serve as a first hint of some kind of brain dysfunction in the early postoperative phase, when a sophisticated assessment of the mental state at the bedside is not possible.

The configural frequency analysis revealed significant relationships between a history of cerebrovascular symptoms and the occurrence of persisting new focal signs in one subpopulation, and of new development reflexes in a second subpopulation. The dichotomy of signs reflected in these configurations could be related either to more global or more focal cerebral manifestations of ischaemia during CABS (Stockard et al. 1973; Malone et al. 1981; Sarnquist 1988). However, the data of our study do not allow any definite conclusions regarding the mechanisms of brain damage (Aberg 1988).

Another notable finding of the present study was the lack of significant correlation between age, preoperative abnormalities, bypass time and the postoperative outcome. This is at variance with the findings of Branthwaite (1972) who found age over 60 and preoperative signs predictive factors of neurological complications; however, considering only slight or moderately severe disturbances our results are similar to the data of Breuer et al. (1983), Smith et al. (1986) and Carella et al. (1988).

All these studies reveal that no single parameter proved significant for neurological risk prediction in CABS. It is therefore tempting to consider that the examination of a greater number of patients with data analysis by means of exploratory multivariate modeling will lead to the selection of an optimal set of various pre- and intraoperative variables which play an important part in the neurologic outcome, perhaps more so than single factors.

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