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# Perioperative fluid and electrolyte management in children undergoing surgery for craniopharyngioma

## A 10-year experience in a single institution

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**Abstract** In a retrospective study, the intra- and early postoperative data of 39 children with 46 operations for craniopharyngioma were analyzed. Diabetes insipidus (DI) occurred in 30 out of 32 cases without preoperative evidence of DI. We observed that all children who did not have a pituitary stalk preserved and 5 out of 7 patients with preserved pituitary stalk developed DI within 18 h of surgery. Short-term inappropriate secretion of antidiuretic hormone (SIADH) occurred in 2 children, but was quickly followed by DI. The time of onset of DI and SIADH did not correlate with sex, age, body weight, location of tumor, or duration or extent of surgery. Parenteral desmopressin was an effective treatment for intra- and postoperative DI. The duration of the clinical effect of desmopressin administration varied in different patients between 4 and 23 h. An approach to the immediate intra- and postoperative management of children with craniopharyngioma is presented.

**Key words** Craniopharyngioma · Desmopressin · Diabetes insipidus · Inappropriate secretion of antidiuretic hormone

## Introduction

The intra- and early postoperative course of children with craniopharyngioma is often complicated by temporary or permanent abnormalities in water homeostasis, such as diabetes insipidus (DI) or the syndrome of inappropriate secretion of antidiuretic hormone (SIADH). Each of these postoperative complications contributes to the morbidity and mortality associated with surgical removal of craniopharygioma [2, 7]. The prompt diagnosis and the appropriate management of DI and SIADH are critical to prevent possible life-threatening complications of the fluid and electrolyte balance. Little has been published on the time of onset and the clinical course of DI and SIADH in children with craniopharyngioma. Although there are published standard approaches to treatment of both DI and SIADH, specifics on the optimal perioperative management to prevent or control these complications are lacking. Therefore, we analyzed 39 children who underwent 46 surgical procedures for craniopharyngioma. On the basis of the initial retrospective analyses of the first 16 children, we developed guidelines for care and now present data relating to the successful implementation of these guidelines in subsequent operations ($n$=30).

## Patients and methods

Our retrospective study included 39 children with histologically verified craniopharyngioma. Between June 1985 and October 1995, 39 patients underwent a total of 46 operations, all performed by one surgeon (the author, N. S.) in the Department of Pediatric Neurosurgery of the University of Würzburg. The records of the pre- and intraoperative periods and the records of the initial postoperative 48 h were analyzed. This time period was chosen because by 48 h after surgery all patients were alert, extubated and taking oral fluids. For the 48 h after the operation, patients were in the intensive care unit. Afterwards, they were routinely transferred to an indermediate ward, where a different management team was encountered. At this time they received the synthetic vasopressin analogue desmopressin (DDAVP) by intranasal administration. There were no episodes of significant fluid and electrolyte disturbances in patients between the analysis period and their discharge from hospital.

According to Lyen and Grant, we defined DI as significant polyuria of diluted urine that responds to treatment with DDAVP [7]. The definition of DI was further restricted to patients with serum sodium above 143 mmol/l and no evidence of fluid overload, hyperglycemia or high levels of urea [10, 11]. SIADH was defined as the spontaneous onset of inappropriate oliguria (<0.5 ml $kg^{-1}$ $h^{-1}$) with concurrent hyponatremia (<135 mmol/l) in the absence of prerenal or renal failure, diluting effects of fluid replacement or gluco- or mineralocorticoid deficiency [1].

Since 1992, a standard approach to intra- and early postoperative care of children with craniopharyngioma has been instituted. If polyuria is detected, fluid replacement is adjusted to match urinary output plus insensible fluid loss. During this period, sodium-free solutions are used exclusively. If evidence for DI has persisted for more than 2 h at a stretch or urinary output cannot be replaced, DDAVP is given intravenously at a low dose (4–20 ng/kg) in conjunction with restriction of fluid intake. Only high-salt-concentration fluids are used (0.7–0.9% NaCl). A higher dose of DDAVP is given if polyuria persists. DDAVP administration is repeated if manifestation of DI recurs. In contrast to DI, the management of SIADH includes immediate restriction of fluid replacement to solutions with a high concentration of sodium.

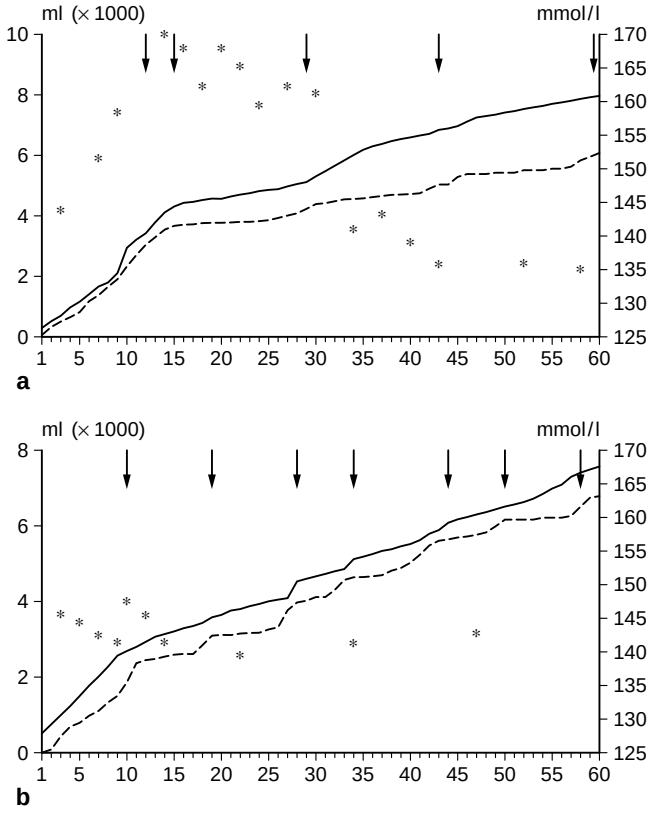


**Fig. 1** Cumulative fluid record for input (——) and output (– – –) (*left ordinate*, in ml×1000) and serum sodium concentration (*) (*right ordinate, in mmol/l*) in a case of **a** inappropriate perioperative management and **b** a case managed according to standard guidelines. The *abscissa* shows the first 60 h after the start of surgery. DDAVP was administered as indicated by the *arrows*

## Illustrative case report

Figure 1a illustrates an inappropriate perioperative management in a 5-year-old boy after total resection of a craniopharyngioma 3 cm in diameter. The pituitary stalk was not preserved. Within the first 13 h of surgery, DI developed (i.e., polyuria with 14 ml $kg^{-1}$ $h^{-1}$), and fluid input was adjusted to fluid output plus an allowance for insensible loss. Because fluid input during DI consisted of solutions with a high concentration of sodium, the serum sodium concentrations rose to 170 mmol/l. Sodium uptake was drastically reduced and DDAVP was given. Serum sodium fell rapidly to 141 mmol/l within 20 h. Figure 1b illustrates a case in which the standard guidelines were appropriately applied and no disturbances of fluid and electrolytes occurred. In this 8-year-old boy a large craniopharyngioma was completely resected; the pituitary stalk was not preserved.

## Results

The 39 patients were between 17 days and 17 years 10 months old (mean, 9 years 4 months). There were 25 males and 14 females. The 39 patients underwent a total of 45 craniotomies, and 1 patient had a transsphenoidal approach. Twenty-nine patients underwent primary surgical resection of craniopharyngioma and in 17 cases removal of the tumor had been attempted previously. The mean duration of surgery was 7 h (range 3–14 h). Total removal was documented in 37 procedures and partial resection, in 9 cases, confirmed by early postoperative computed tomography scan. In 7 cases the pituitary stalk was identified and preserved. There were no deaths within 30 days of the operation. Major complications were encountered in 3/46 procedures; they included subdural effusion requiring shunting, cerebral infarction, and blindness.

Preoperative evaluation indicated that for all patients electrolyte levels were in the normal ranges. As routine therapy, glucocorticosteroids (dose range 8–16 mg $kg^{-1}$ $day^{-1}$) were given pre- and postoperatively. In the preoperative period, DI was diagnosed in 14 cases, and all these patients were treated with DDAVP (Fig. 2). Of the 32 patients in whom there was no evidence of preoperative DI, 5 developed DI during surgery. Of 27 patients who did not have pre- or intraoperative DI, 25 developed manifestations of DI within 18 h (median 9 h) of surgery (Fig. 2).

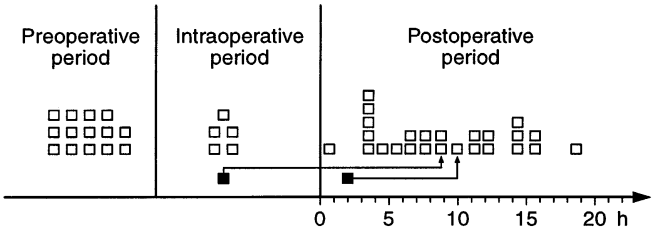


**Fig. 2** Time of onset of DI (□) and SIADH (■) in 39 children with 46 surgical operations for craniopharyngioma. Both episodes of SIADH were followed by DI

**Table 1** Comparison of intra- and early postoperative sodium fluctuation for the periods 1985–1991 and 1992–1995

| Time period<br>No. of operations | 1985–1991<br>*n*=16 | 1992–1995<br>*n*=30 |
|---|---|---|
| Max. sodium (mmol/l) | | |
| Mean | 149.8 | 145.2 |
| Range | 140–170 | 135–155 |
| Min. sodium (mmol/l) | | |
| Mean | 136.3 | 135.8 |
| Range | 122–144 | 127–142 |
| Sodium >150 mmol/l | 8** | 2** |
| Sodium <130 mmol/l | 2 | 2 |
| Sodium disturbances | 10* | 4* |

* $P<0.005$; ** $P<0.001$ (Chi-square)

All patients without preserved pituitary stalk developed DI. Early postoperative DI was also seen in 5 out of 7 patients whose pituitary stalk had been preserved intraoperatively. No correlation could be found between the incidence or the time of onset of DI and sex, age, body weight, location of tumor, or duration and/or extent of surgery. SIADH was noted in 2 of 32 cases without DI prior to surgery. In 1 case SIADH developed during surgery and in the other case, 2 h after the end of surgery; SIADH was followed by DI after 9 h and 10 h, respectively (Fig. 2). In both patients, total tumor removal was achieved, but the pituitary stalk was not preserved. In only 2 patients was there no evidence of intra- and early postoperative DI or SIADH. Interestingly, in both of these patients, the pituitary stalk had been preserved.

Parenteral DDAVP resulted in oliguria/anuria lasting between 4 h and 23 h (median 10 h). For each individual patient, the effect of DDAVP varied by not more than 5 h (median 3 h).

Following the adoption of standard guidelines for intra- and postoperative care of children undergoing surgery for craniopharyngioma in 1992, the frequency of intra- and early postoperative complications of fluid and electrolyte disturbances decreased (Table 1). The groups compared did not differ significantly in age, frequency of primary and recurrent tumor, partial or complete resection of the tumor, and preservation of pituitary stalk.

## Discussion

The incidence of intra- and postoperative DI in the present study was similar to the rates cited in other reports and is higher in children with craniopharyngioma than in those with other intracranial tumors [2, 5]. When DI occurred in a patient at our institution, it developed not later than 18 h after the end of surgery. No correlation between the extent of tumor resection and the incidence of DI was found, which is in contrast to the report of Bucci et al. [3]. This might be explained by remembering that, in addition to axonal damage by surgery, other factors, including alterations in blood flow, metabolic activity, and individual variation, influence the extent of axonal degeneration, which determines whether DI occurs or not [12]. This is further supported by the fact that in our study population, 5 out of 7 patients with preserved pituitary stalk developed DI. SIADH was observed in 2 patients, in neither of whom the pituitary stalk had been preserved.

The pathophysiology of postoperative SIADH is still unclear. Postulates include secretion of a bolus of antidiuretic hormone by the posterior pituitary when deprived of normal regulation and release of antidiuretic hormone provoked by elevation of intracranial pressure [4, 6]. In our patient population, in both episodes of SIADH the effects were short-lived and rapidly followed by DI. It is not possible to determine in our study population whether any episode of SIADH may have followed DI, since DI was treated with DDAVP, which induced temporary oliguria or anuria. This might also explain why we observed only two episodes of SIADH and could not find the triphasic pattern, DI-SIADH-DI, reported by Verbalis et al. [12].

The unpredictable onset of DI and SIADH makes the intra- and early postoperative management of children with craniopharyngioma a continuing challenge to the clinician. Significantly fewer disturbances in the salt-to-water ratio have occurred since the guidelines touched on above were adopted. Disturbances of the fluid and electrolyte homeostasis have been seen in only 4 of the 30 subsequent patients. In 1 of the patients the recommended guidelines were not applied appropriately: after DDAVP had induced oliguria, fluid input with sodium-free solutions was not reduced and hyponatremia occurred. The 3 other patients were 3 and 4 years of age, respectively, which is below the average age of the children of our study population. We surmise that the young child, in particular, may be especially vulnerable to fluid and electrolyte disturbances, which is in agreement with the report of Choux et al. [5]. The prompt and adequate replacement of urinary fluid loss and of electrolyte loss in DI and SIADH may be facilitated by the preparation of two different solutions, one without sodium and the other with a high sodium concentration. Parenteral DDAVP should be given when urinary fluid loss cannot be replaced or DI lasts for longer than 2 h. Although

the clinical effect of DDAVP administration was consistent in each patient, the duration of the effect of DDAVP administered i.v. varied considerably between individuals. This had also been found for DDAVP given intranasally and was thought to be due to differences in absorption of DDAVP from the nasal mucosa [9]. The differences in the duration of action of parenteral DDAVP may be explained by different plasma half-life of DDAVP, dynamics of binding at the renal cell membrane, or local degradation at the binding site [8].

In summary, in all the patients analyzed, the onset of DI or SIADH occurred during surgery or the first 24 h after surgery. The practical guidelines presented have significantly improved the perioperative care of children operated on for craniopharyngioma in our hospital and should be tested in other institutions.

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