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Duration of intravenous fluid replacement after abdominal surgery: a prospective randomised study

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This prospective randomised study examined the possibility of early resumption of oral hydration and discontinuation of intravenous fluid replacement after emergency or elective abdominal surgery. Following elective cholecystectomy alone or with a choledocholithotomy or an emergency Hartmann's procedure for large bowel obstruction, patients were randomised to early oral hydration (sips of water for 12 h followed by free fluids by mouth for 24 h, when oral intake of food was allowed—intravenous hydration was discontinued 6 h after starting the intake of free fluids orally) or conventional intravenous hydration (intravenous hydration and an oral regimen of water as follows: sips every hour for 12 h, 30 ml every hour for 24 h, 60 ml every hour for 24 h, 90 ml every hour for 24 h, free fluids for 12 h, when food was allowed—intravenous hydration was discontinued 6 h after starting the free fluids). The two regimens were equally effective in maintaining fluid balance and normal plasma and urinary electrolytes without any observed differences in biochemical or metabolic values. Each of free fluids by mouth, discontinuation of intravenous hydration, and consumption of solid food were achieved in the patients on early oral hydration at time periods significantly shorter than those attained with the conventional regimen ($P < 0.001$). Similarly, patients on the latter regimen were hospitalised for significantly longer times than those on early oral hydration ($P < 0.001$).

Early oral hydration after biliary surgery or a Hartmann's procedure effectively maintains fluid balance and has advantages over the conventional intravenous hydration regimen.

Laparotomy produces intestinal motor disturbances that cause a transitory suppression of gastrointestinal motility (ileus) (*1–5*). The cause is believed to be an inhibitory reflex activated by laparotomy, which involves the spinal cord and splanchnic nerves and produces sympathetic hyperactivity (*6,7*). Depression of the cholinergic excitatory system may also be implicated in the pathogenesis (*8–10*).

Because postoperative gastrointestinal atony can develop after virtually all surgical operations, particularly those involving intraperitoneal procedures, it is widespread practice to restrict oral intake in the immediate postoperative period and to hydrate the patient by intravenous fluids. There are no publications which reliably determine the necessary duration of oral restriction and intravenous hydration after elective or emergency intraperitoneal surgery. Since small intestinal function usually recovers rapidly after intra-abdominal surgery, in contrast to the prolonged suppression of the motility of the stomach and colon (*1*), oral hydration and discontinuation of intravenous replacement may be feasible in the early postoperative period, particularly in the absence of factors that can perpetuate atony such as sepsis and/or the presence of intraperitoneal necrosis and devitalised tissues or factors demanding caution with oral intake such as gastrointestinal anastomoses or extensive mobilisation of the peritoneum.

This study was designed to examine the possibility of early resumption of oral hydration and the early discontinuation of intravenous fluid replacement after elective and emergency intraperitoneal surgery.

Patients and methods

Patients

A prospective, randomised trial was conducted on consecutive patients who had undergone either elective cholecystectomy with or without an exploration of the

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common bile duct or an emergency Hartmann's operation for an obstructing sigmoid carcinoma. Informed consent was obtained from all patients and they were randomised immediately after surgery to one of the study regimens by drawing sealed envelopes (alternating sequence).

A patient was initially judged suitable for the study only if the following conditions were absent: septicaemia, fever, peritonitis, ileus, insulin-dependent diabetes, significant symptoms from other gastrointestinal disorders which would make it difficult to evaluate the trial regimens (for example, severe irritable bowel syndrome, oesophagitis, hiatus herniation, or peptic ulceration), hypertension, cardiorespiratory problems, hepatic or renal disorders.

Standard haematology measurements, full biochemical screening, and 24 h urine examination, and the recording of fluid intake and output were carried out on each of the first 4 postoperative days. In addition, on the 2nd and 4th postoperative days patients were weighed and their blood gases, blood glucose, and serum lipids determined. All patients were seen twice daily on each of the first 5 postoperative days, unless they had been discharged earlier, and asked about nausea, vomiting, abdominal pains, the first occurrence of flatus, and passing urine. Then the abdomen was auscultated for propulsive bowel motility. Tolerance of free fluids, discontinuation of intravenous replacement, return to normal diet, and day of discharge were recorded.

The endpoint of the study was the return to and tolerance of normal diet in the absence of gastrointestinal atony (auscultatory silence, no flatus, no stools).

Methods

Postoperative regimens

All emergency cases were fasted and intravenously hydrated immediately after admission to hospital. An intravenous line was established by the anaesthetist after induction in elective cases. Identical prophylactic antibiotics were given intravenously to all patients as a single dose at induction of anaesthesia. Postoperatively, patients were randomised to one of two regimens:

1. *Early oral hydration.* When awake, patients were offered sips of water every hour for 12 h then allowed free fluids by mouth (more than 100 ml/h of tap water or fruit juices) for 24 h. If these volumes were well tolerated and if the gastrointestinal tract had already resumed its propulsive motility, the intravenous line was disconnected after 6 h of commencing the free fluid intake. Twenty-four hours after starting the latter intake, patients were given solid food.
2. *Hydration by conventional intravenous fluids.* When awake, patients were instituted on the following regimen of water orally: sips every hour for 12 h, 30 ml every hour for 24 h, 60 ml every hour for 24 h, 90 ml every hour for 24 h. Thereafter, they were offered free fluids, as above, and if these were being tolerated comfortably, the intravenous line was disconnected 6 h later. Solid food was allowed 12 h after starting the intake of free fluids.

The postoperative intravenous fluids were the following 4–6 h regimen: 500 ml 0.9% NaCl, followed by 2 × 500 ml 5% glucose. Starting 24 h postoperatively, 13.5 mmol KCl were added to each glucose container.

After choledocholithotomy, a T-tube was placed in the common bile duct. Unless contraindicated, these patients were discharged home to be readmitted for removal of the T-tube.

Exclusion criteria

Patients initially judged suitable for the study were not randomised if they were found to have co-existent duodenal ulceration or another intraperitoneal pathology requiring surgery perioperatively.

After randomisation, exclusion from analysis was based on the following rules which were strictly applied and any infringements led to the omission: (1) intolerance to the regimen, (2) failure to comply accurately with the regimen, and (3) concomitant postoperative treatment with parasympathetic drugs (eg cisapride, neostigmine, bethanechol), sympathicolytics (eg trifluperidol, chlorpromazine) or gastrokinetics (metoclopramide, domperidone).

Statistical analysis

The χ^2 test with Yates' correction was used to compare different frequencies of the assessment parameters between groups and the Mann–Whitney U test was used to compare the significance of observed differences in mean values between groups.

Results

Patient characteristics

In the cholecystectomy alone groups, 43 patients (29 women and 14 men) with an age range of 29–74 years (mean 52 years) were randomised to receive early oral hydration and 42 patients (26 women and 16 men) with an age range of 26–71 years (mean 51 years) were randomised to receive intravenous hydration. In the cholecystectomy with choledocholithotomy group, 31 patients (23 women and 8 men) with an age range of 31–68 years (mean 48 years) were randomised to receive early oral hydration and 30 patients (24 women and 6 men) with an age range of 29–66 years (mean 49 years) were randomised to receive intravenous hydration. In the Hartmann's group, 21 patients (17 men and 4 women, age range 51–74 years, mean 62 years) were randomised to early oral hydration and 22 patients (16 men and 6 women, age range 53–69 years, mean 61 years) were randomised to have intravenous hydration. There were several exclusions in each group after randomisation and

Table I. Patient characteristics

	Cholecystectomy		*Cholecystectomy + choledocholithotomy*		*Hartmann's procedure*	
	Oral	*IV*	*Oral*	*IV*	*Oral*	*IV*
n	37	29	23	19	11	11
Age (years)						
Range	30–74	28–71	31–68	30–66	53–71	53–67
Mean	51	50	49	50	64	60
Males	10	8	5	4	8	9
Females	27	21	18	15	3	2

Oral: Early oral hydration
IV: Hydration by conventional intravenous fluids

the characteristics of the fully evaluable patients are shown in Table I.

Comparisons between the groups

All the emergency operations were carried out within 12 h of admission to hospital. Two cases in each of the groups undergoing a Hartmann's procedure required perioperative blood transfusion. One patient (Hartmann's procedure) died because of bronchopneumonia. None of the remaining patients had impaired consciousness or was ill to such an extent that reporting of the first occurrence of postoperative events was likely to be unreliable. Intolerance to the hydration regimen was of a sufficient magnitude to lead to exclusion from analysis in two patients on early oral hydration and in five patients on intravenous hydration in the cholecystectomy groups; in two patients on early oral hydration and in three patients on intravenous hydration in the cholecystectomy with choledocholithotomy groups; and in three patients on early oral hydration and in two patients on intravenous hydration in the Hartmann's procedure groups. The frequency of postoperative nausea and/or vomiting, gastrointestinal atony (ileus), and intolerance to the hydration regimen was not significantly different between the patients on early oral hydration and those on hydration by conventional intravenous fluids in each of the study groups. Nevertheless, it was noted that the incidence of postoperative nausea and/or vomiting and gastrointestinal ileus was less frequent in the patients on early oral hydration (Table II).

In each of the early oral hydration groups, bowel sounds were heard at significantly earlier time periods than those in the groups offered conventional intravenous hydration ($P<0.01$) (Table II). Because of the difference in the postoperative regimens, tolerance of free fluids by mouth followed by the return to solid food intake was achieved at significantly earlier times with early oral hydration relative to those with intravenous hydration ($P<0.001$) (Table II). Consequently, disconnection of the intravenous line in each of the early oral hydration groups was attained at earlier times than those of the intravenous hydration groups ($P<0.001$).

After biliary surgery and in the absence of contraindications, patients were discharged from hospital when they remained comfortable with solid food after at least

Table II. Comparison between the groups

	Cholecystectomy		*Cholecystectomy + choledocholithotomy*		*Hartmann's procedure*	
	Oral	*IV*	*Oral*	*IV*	*Oral*	*IV*
Patients having nausea/vomiting (*n*)	1	4	2	3	3	5
Patients developing ileus (*n*)	0	2	0	1	1	2
Return of bowel sounds	18 ± 0.4	26 ± 0.2	20 ± 0.1	29 ± 0.3	21 ± 0.3	30 ± 0.4
Tolerance of free fluids by mouth	20 ± 0.3	93 ± 0.4	21 ± 0.1	94 ± 0.3	22 ± 0.2	94 ± 0.6
Duration of intravenous hydration and the time when intravenous line was disconnected	21 ± 0.1	94 ± 0.5	21 ± 0.2	94 ± 0.4	23 ± 0.4	95 ± 0.5
Intake of solid food	41 ± 0.2	101 ± 0.2	42 ± 0.1	102 ± 0.3	43 ± 0.3	103 ± 0.3
Length of postoperative hospitalisation	67 ± 0.4	125 ± 0.3	68 ± 0.3	127 ± 0.2	162 ± 0.8	211 ± 0.5

Values are the mean postoperative hour ± sem or the number of patients (*n*)
Oral: Early oral hydration
IV: Hydration by conventional intravenous fluids

three meals. In the groups orally hydrated, this was achieved at significantly earlier times than those of the patients hydrated intravenously ($P<0.001$) (Table II). After a Hartmann's procedure, discharge from hospital was after the colostomy had functioned satisfactorily and after the patient had learned to manage the colostomy bag. The patients that were offered early oral hydration were discharged from hospital at significantly earlier times than those of the patients hydrated intravenously ($P<0.001$) (Table II).

Fluid balance

There were no obvious regimen-related changes in haematology or biochemistry values or in the fluid balance. Postoperative haemoglobin, plasma electrolytes and plasma urea and creatinine were normal in all members of the study groups. Both early oral hydration and intravenous hydration patients were oliguric on the day of operation. Later, normal outputs were noted by the second postoperative day in the early oral hydration groups and by the third postoperative day in the intravenous hydration groups. In the immediate postoperative period, urinary excretion of sodium and potassium was high in members of both regimens, values falling by the 2nd postoperative day in the early oral hydration groups and by the 3rd postoperative day in the intravenous hydration groups.

Metabolic assessment

The metabolic influences of both regimens were similar and the screening carried out to study this aspect of the postoperative phase revealed no significant differences in serum proteins, serum lipids, blood glucose, blood gases and pH value, urinary nitrogen, and body weight between the regimens.

Discussion

The results demonstrate that early oral hydration effectively maintains fluid balance and is well tolerated by most patients after biliary or colonic surgery. This regimen has obvious advantages over the conventional method and produced no adverse haematological, biochemical, or metabolic effects. The oral intake of free fluids followed by solid food was achieved at significantly shorter times with early oral hydration relative to those with the conventional regimen (Table II). The benefits incurred by an earlier return to normal diet with its advantageous nutritional support at a time when this is most needed cannot be overemphasised. In addition, the intravenous line was disconnected sooner in the early oral hydration patients in comparison to those hydrated intravenously. This allowed patients free movement and greater comfort. Consequently, these patients were more co-operative with the hospital staff and were more interested and participated more actively in their postoperative programmes (eg mobilisation, physiotherapy, stoma care, etc.). Another major advantage of the early oral hydration regimen is that it enabled an expeditious discharge of patients from hospital relative to that with the conventional regimen. This point is extremely important, for any measure that speeds patient rehabilitation will ease bed pressure and contribute to financial savings.

The incidence of postoperative nausea and/or vomiting and gastrointestinal ileus was less in the patients given early oral hydration. This observation suggests that in the absence of factors capable of promoting or continuing postoperative gastrointestinal atony, and after allowing the gastrointestinal tract sufficient time to recover from the effects of perioperative handling and anaesthesia, an early return to oral intake of free fluids may produce a functional demand that speeds recovery of gastrointestinal motility. The fact that bowel sounds were heard significantly earlier in each of the early oral hydration groups supports such a suggestion.

After abdominal surgery, the motility of the entire gastrointestinal tract is inhibited and recovery occurs gradually from the stomach to the rectosigmoid (*1,2*). The recovery of myoelectric activity occurs as incoordinated motility at first, followed by a progressive restoration of the organised fasted pattern where the migrating myoelectric complex assumes the normal propulsive and secretory function (*1,2*). The stomach resumes its activity first (*1*), although gastric emptying of solids may be delayed for up to 48 h after surgery (*3*), and the small bowel follows usually within 7 h (*1*). The left colon, however, is the last to recover its electrical and contractile activity (*1,2*). In man, although postoperative radiological investigations attribute normal propulsive activity to the small intestine (*4*), a disturbance in the coordination of myoelectric activity in the early postoperative period has been demonstrated, with disruption of the slow waves that constitute the basic electrical rhythm and irregular occurrence of spiking activity (*5*). Nevertheless, from a functional point the small intestine regains its motility rapidly and before the stomach and colon (*1*). This last point may be the crucial factor enabling early postoperative oral hydration.

The results of this study are in agreement with those showing that after cholecystectomy or appendicectomy an intravenous infusion is not needed and that patients can be effectively hydrated by mouth (*11,12*).

It was impossible to perform this study in a blind way, because symptoms had to be recorded and fluid balance had to be carefully monitored. However, patients receiving either regimen were equally encouraged to comply with their postoperative programmes and those failing to do so were excluded from the study. This compliance was similar among the study groups and, therefore, the results of the present investigation cannot be ascribed to differences in patients' compliance or to an unintended bias in favour of a particular group which may influence its compliance.

It might be argued that bowel sounds and the expulsion of intestinal gas are rather insensitive indicators of gastrointestinal motility and in part rely upon uninhibited full co-operation of the patient, who had to report

whether or not gas has been passed. Objective recording techniques would certainly improve the sensitivity of the results. However, passage of distinct flatus could be indicative of propulsive colonic activity (*10*). In fact, neither the recording of pressure from one site of the colon (*1,13*), nor the return of normal frequency of electrical spike discharge by themselves necessarily correlate with the presence of propulsion or with the time at which gas is expelled from the rectum (*13*). It should be stressed, however, that the endpoint of the present study was the return to ingestion of solid food and that functional recovery was considered to have been achieved when patients were comfortably tolerating this food without complications and not when bowel sounds were heard or when intestinal gas was expelled.

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Notes on books

Surgery of the Thymus edited by Jean-Claude Givel. 345 pages, illustrated. Springer-Verlag, Berlin. 1990. DM298. ISBN 3 540 16315 8

For many surgeons the thymus is a gland of mystery. This comprehensive and well-produced volume will solve the mystery, for it covers all aspects of pathology, investigation and treatment for disorders of the gland. It also includes an excellent historical review by the editor. Extensively referenced, this volume should become the definitive text on the thymus gland for the next decade.

Arthroscopic Atlas of the Temporomandibular Joint by David I Blaustein and Leslie B Heffez. 117 pages, illustrated. Lea & Febiger, Philadelphia. 1990. £44.69. ISBN 0 8121 1242 3

A large format and well-illustrated colour atlas describing and illustrating arthroscopy of the temporomandibular joint.

Ultrastructure of Skeletal Tissue: Bone and Cartilage in Health and Disease edited by E Bonucci and P M Motta. 299 pages, illustrated. Kluwer Academic Publishers, Boston. 1990. £127.00. ISBN 0 7923 03730 3

Extensively illustrated with light micrographs and electron micrographs this volume collects together recent data on the ultrastructure of cartilage and bone both normal and pathological. Of interest to the orthopaedic surgeon.

Clinical Applications of Ventilatory Support edited by Robert R Kirby, Michael J Banner and John B Downs. 546 pages, illustrated. Churchill Livingstone, New York. 1990. £49.95. ISBN 0 443 08613 3

This book represents an update of *Mechanical Ventilation* published in 1985. New chapters include one on anaesthesia ventilators and the outcome of treatment for acute and chronic respiratory failure. All other chapters have been brought up to date.