Gastrointestinal decontamination in acute toxic ingestions

P. Lheureux, R. Askenasi, F. Paciorkowski

Emergency Department, Acute Poisoning Unit, Erasme University Hospital, Brussels.

Introduction

The overall mortality from acute poisoning is less than 1% and the challenge for clinicians managing poisoned patients is to identify at an early stage those who are most at risk of developing serious complications and who therefore might potentially benefit from specific measures (decontamination, enhancement of elimination, pharmacological antidotes), in addition to general supportive care ; and to avoid unuseful and potentially dangerous interventions in others.

The vast majority of poisoning cases observed in Emergency Departments occur by ingestion : decontamination procedures intend to limit absorption and toxicity may thus be indicated. Some of these procedures have been performed routinely for many years, based on pharmacologic studies in animals and humans without demonstration a reduction of morbidity and mortality in controlled clinical studies. Moreover, each of these techniques is associated with a non negligible risk of complicatons. This topic has been the subject of a recent reappraisal to better evaluate their efficacy and risks and define their actual indications (1-5).

Prevention of GI tract absorption first consist of placing the patient in the left lateral decubitus position ("lateral safety position"). In addition to decreasing risks of airway compromise and pulmonary aspiration, it significantly reduces the transit of the ingested medications through the pylorus and into the small intestine, where the vast majority of absorption occurs. It should be adopted as the standard position for transport of patients until a decision is made concerning further decontamination procedures (6).

Methods to prevent absorption can be classified in three categories : gastric emptying (induction of emesis, gastric aspiration and lavage), adsorption in situ (administration of activated charcoal and rarely other adsorbants), expulsion of gut content (cathartics, whole bowel irrigation). The present paper will briefly review the practical aspects of each technique, their rationale, their potential complications and their contraindications.

Induction of emesis

Based on early studies (8,9), often with questionable clinical relevance, induction of emesis, especially by administration of syrup of ipecac, has long been accepted as a common method to empty the stomach in poisoned patients, particularly in children at home and in alert adult patients in the Emergency Department. Later studies in human volunteers (10-12) have however suggested that the recovery of ingested product from lavage could be superior to the recovery from syrup of ipecac and the procedure came under increased criticism in recent years.

Indeed, studies consistently show that ipecac effectively induces emesis, but only reduces absorption by about 10-30 percent. Ipecac induced emesis is associated with a 15-30 min delay until vomiting occurs, allowing further absorption of toxins. If ipecac fails to induce emesis, dosing must be repeated after 20-30 min. Excessive administration of fluids, associated with ipecac syrup, promotes absorption because of the increased tablet dissolution and propulsion of the toxin into the duodenum. Finally, induction of emesis is only possible in fully alert and stable patients, with minimal risk of clinical deterioration in the next hour (13,14). Actually, no human study supports the use of ipecac, even when administered within a short time of drug ingestion (15,16) Therefore, the clinical yield of induced emesis appears highly questionable and is likely very limited (17).

Indications

Administration of syrup of ipecac has long been a routine procedure for alert patients who have no contraindication. Although ipecac syrup could have some usefulness at home in the immediate management of poisoning in children, especially if activated charcoal in a practical form is not readily available, it now appears that it has no more place in the Emergency Department.

Adverse effects and contraindications

Induction of emesis by ipecac may be associated with protracted vomiting that delays administration of activated charcoal (13,18). Syrup of ipecac seems to have a good safety profile, as sugested by the low rate of reported complications and the impressive number of doses that were administered in the past. However,

Lecture presented at the Meeting of the *Société Royale Belge de Gastro-entérologie*, Brussels, October 25, 1997.
Address : Prof. P. Lheureux, Department of Emergency Medicine — Acute Poisoning Unit, Erasme University Hospital, Route de Lennik 808, B-1070 Brussels.

Table I. — **Complications reported after induced emesis or gastric lavage**

IPECAC syrup	Gastric lavage
Neurological drowsiness (1-20% children and elderly) agitation (8-10%) cerebral hemorrhage *Digestive* intractable vomiting (6-17%) dehydration, electrolyte disturbances esophagitis, Mallory-Weiss syndrome abdominal pain and cramping (3-8%) diarrhea (8-28%) pneumoperitoneum, pneumomediastinum *Respiratory* apiration pneumonia	*Respiratory* laryngospasm hypoxemia aspiration pneumonia tension pneumothorax empyema *Cardiovascular* tachycardia or vagal bradycardia supraventricular or ventricular prématurebeats ST elevation *Digestive* frequent superficial erosions esophageal perforation (1/15000) GI hemorrhage *Metabolic* hypernatremia water intoxication *Ocular* conjonctival hemorrhage

serious adverse effects have occasionally been reported (Table I).

Contraindications are numerous (13). Coma, seizures, ingestion of proconvulsant drugs or agents inducing rapid alteration of consciousness, pregnancy, bleeding disorders, spontaneous vomiting, cardiovascular disorders, corrosive or hydrocarbons ingestion (risk of chemical pneumonitis) are all absolute contraindications to use of ipecac, as those who have co-ingested sharp objects (13,15). Caution is also recommended in patients bradycardia since emesis may be associated with a vagal reflex (15), and in very young (less than 6 months) or very old patients.

Gastric lavage

Gastric aspiration and lavage is another classical procedure of gastric emptying. It should only be undertaken by experienced staff within the Emergency Department or the Intensive Care Unit (19). All the equipment for emergency respiratory care must be ready and patients with impaired consciousness or gag reflex must be previously intubated. The proper technique requires the passage of a large-bore (36 to 40 French gauge in an adult, 16 to 28 French gauge in children) orogastric tube with rounded end. Once the tube is passed, its position should be checked either by air insufflation, while listening over the stomach. An aliquot of gastric aspirate must be retained for possible toxicologic analysis, since it may contain high concentration of non-metabolized toxins. Limited aliquots (250 to 300 mL in adults, 10 to 20 mL/kg in children) of fluid must be sequentially instilled and recovered by gravity or aspirated until the return is clear (19). Tap tepid water (38°C) may be used in adults, saline or semi-saline is recommended in small children 10 to prevent development of hyponatremia. Left lateral decubitus and Trendelenbourg positions must be combined to prevent aspiration and to collect the gastric content in the fundus, thereby minimizing the risk of flushing the toxins through the pylorus (19,20). Patients with decreased alertness or impaired gag reflex must be intubated.

As compared to ipecac-induced emesis, gastric lavage has some advantages : lack of latency, control of lavage duration, direct access for instillation of activated charcoal. However, gastric lavage is an invasive procedure and serious complications have occasionnally been reported. The technique is difficult and associated with high risks in conscious but non-compliant patients. Limited recovery of gastric content has also been demonstrated in both experimental animal and volunteer studies, even when lavage is performed within 60 min of ingestion. Gastric lavage appears more effective than ipecac when performed immediately after exposure (10,21) but this advantage disappears at 1 hour postingestion (22,23). Therefore, gastric lavage should not be employed routinely in the management of poisoned patients (1,19).

The clinical value of gastric lavage depends on many factors (1) : time elapsed between ingestion and lavage, amount ingested, form of the ingested toxin (tablets, powder, liquid), site and rate of absorption, inherent toxicity of the substance. Although removal of impressive amounts of unabsorbed drug has been anecdotally documented, it unfortunately concerns in a small minority of patients who can not be identified. As a general rule, the efficacy of gastric lavage after the first 1 to 2 h post ingestion is highly questionable in all but the most serious cases. In the single clinical study

(24) in which a benefit from lavage, in addition to administration of activated charcoal, was suggested, this effect was limited to patients with impaired consciousness less than 1 hour after overdose. Lavage after this period may however be appropriate in the presence of documented gastric concretions, delayed gastric emptying, or sustained-release preparations (1).

Indications

Gastric lavage may be useful for patients who have ingested a life-threatening dose of highly toxic substances or who exhibit significant morbidity and who present within 1 to 2 hours after ingestion, especially when similar prevention of further absorption can not be expected from administation of activated charcoal alone. Involvement of drugs that delay absorption, ingestion of large amounts, and absence of bowel sounds may lead to increased drug recovery at later times, but whether these patients benefit from lavage as long as 4 to 6 hours postingestion remains uncertain (25,26). For minor to moderate ingestions of toxic substances that are adsorbed to activated charcoal (Table II), activated charcoal is preferred to gastric lavage (2,27).

Gastric pharmacobezoars may develop with some substances (salicylates, barbiturates, meprobamate, sustained-release formulations). They can be been successfully fragmented or removed by lavage, directly oriented by endoscopy. This procedure may avoid surgical removal through gastrotomy that otherwise may be indicated if there is evidence of continuing toxicity or in high risk situations or (1,28).

Adverse reactions and contraindications

Toxin absorption may be enhanced by gastric lavage. Reported complications are summarized in table I and mainly include laryngospasm, hypoxemia, aspiration pneumonia, bradycardia, ST elevation on the electrocardiogram, and rare mechanical injury to the gastrointestinal tract (1,19).

Lavage is absolutely contraindicated in patients with an unprotected airway, such as patients with a depressed state of consciousness, and in patients at risk of hemorrhage or perforation due to pathology or recent surgery (19). Relative contraindications to gastric lavage are ingestion of hydrocarbons, corrosives and risk of hemorrhage or perforation due to pathology or recent surgery. Lavage is not useful in non toxic ingestions or as a deterrent to subsequent intentional intoxication (19).

Table II. — **Adsorption of drugs and other substances to activated charcoal in vitro**

Well Adsorbed	Moderately Adsorbed	Inadequately Adsorbed
Aflatoxins	Aspirin and other salicylates	Cyanide
Amphetamine	DDT	Ethanol
Antidepressants	Disopyramide	Ethylene glycol and other glycols
Antiepileptics	Kerosene, benzene, dichlorethane	Iron
Antihistamines	Malathion	Lithium
Atropine	Many NSAID	Methanol
Barbiturates	Mexiletine	Strong acids and alkalis
Benzodiazepines	Paracetamol	
Beta blocking	Polychlorinated biphenyl compounds	
Chloroquine	Phenols	
Primaquine		
Cimetidine		
Dapsone		
Dextropropoxyphene other opioids		
Digitalis glycosides		
Ergot alcaloids		
Furosemide		
Glutethimide		
Indomethacin		
Meprobamate		
Nefopam		
Oral hypoglycemiants		
Phenothiazines		
Phenylbutazone		
Phenylpropanolamine		
Piroxicam		
Quinidine and quinine		
Strychnine		
Tetracyclines		
Theophylline		

Adapted from NEUVONEN P.J., OLKOLLA K.T. *Med. Toxicol.*, 1988, **3** : 33-58.

Activated charcoal

Since the early 1980s, activated charcoal has gained increasing popularity as the first choice mean of gut decontamination based on its relative lack of adverse effects (29,30) and on human volunteer studies that suggested a superior efficacy, when administered early after ingestion (23), and a lower complication rate, as compared to emptying procedures.

Radiologic and endoscopic studies (31,32) in overdose patients indicated that neither emesis nor lavage removes all intragastric solids, including tablets. Ipecac delays the administration of activated charcoal (18) and no additional benefit can usually be expected from emptying procedures before administration of activated (30). Moreover, they increase the prevalence of ICU admissions and the need for respiratory support, probably because a higher incidence of pulmonary aspiration (30). Therefore, activated charcoal is now considered as the agent of choice for gastrointestinal decontamination and is emerging as the single decontamination measure in most instances (2,18,29,33 34,35).

Activated charcoal inhibits the absorption and prevents the systemic toxicity by adsorbing chemicals on its surface. The adsorptive surface area of regular activated charcoal is 1200-1500 m^2/g; technologic advances have produced super activated charcoals with adsorptive surface area greater than 3000 m^2/g (2).

Indications

Activated charcoal is now commonly administered in the majority of poisoning cases admitted within a few hours in the Emergency Department, provided no contraindication exists, although this attitude is not clearly supported by clinical studies. The commonly recommended dose is 50-100 g in adults (1-2 g/kg in children) in the form of a fluid slurry (water/charcoal 4:1 v/v) administered orally or through a common nasogastric tube. A minimal ponderal charcoal/toxin ratio of 10:1 is usually advocated, based on in vitro measurements (2). The continuous instillation of activated charcoal in the duodenum may improve the retention of the adsorbant in patients with protracted vomiting (e.g., theophylline overdose).

When gastric lavage is required, a first dose of activated charcoal should be administered through a small-bore nasogastric tube while high-priority procedures (airway control, intravenous access, cardiac monitoring) are in progress. Lavage with a large-bore orogastric tube can then be performed. Administration of charcoal is repeated at the end of the procedure (36).

Serial doses of activated charcoal is increasingly used as a method to enhance elimination of some toxic compounds, as an alternative to other techniques such as hemodialysis or hemoperfusion. Indeed, this procedure has been shown to increase the clearance and reduce the half-life of a number of drugs. The mechanism.wich likely involves interruption of the enterohepatic circulation and direct "dialysis" from capillaries in the gastrointestinal mucosa (2) is sometimes called "enterodialysis". Enterodialysis can be considered in serious poisonings involving some drugs (Table III), including phenobarbital, theophylline,dapsone, digitalis glycosides (especially digitoxine) or quinine.

Table III. — **Multiple doses of activated charcoal**

Very effective	Digitoxine Phenobarbital Theophylline Dapsone Carbamazepine Quinine
Probably effective	Digoxine Meprobamate Some betaadrenergic blockers Diazepam Phenytoine
Doubtful effect	Antidepressants Salicylates Phenylbutazone

Adverse effects and contraindications

Disadvantages of activated charcoal include poor patient acceptance due to the aspect of the slurry (however tasteless and odourless) and the rather frequent development of vomiting (2,37). Pulmonary aspiration may result. Constipation and even gastrointestinal obstruction, particularly in the caecum, have been reported in patients with dehydration; usually after administration of multiple doses of activated charcoal, whatever cathartics are administered (38,39) or not (40).

A few substances are not absorbed by activated charcoal (Table II), including alcohols, glycols, iron sulfate, lithium salts and cyanide (2,37). Administration of charcoal is contraindicated in the presence of ileus or bowel obstruction and prior to endoscopy after corrosive ingestion unless there is a compelling need to adsorb another ingested toxin (2,37).

Cathartics

Saline (e.g., magnesium citrate, magnesium sulfate, sodium sulfate, disodium phosphate) or saccharides (e.g., sorbitol, mannitol, lactulose) have been widely used in poisoned patients. They induce osmotic retention of fluid within the gastrointestinal tract probably activating motility reflexes and enhancing expulsion (41,42). Sorbitol is now the cathartic of choice because it may be more effective than saline cathartics (43,44). In addition, sorbitol improves the palatability of activated charcoal and perhaps provides a bacteriostatic environment. The usual dose is 1 to 2 mL/kg of a 70% solution of sorbitol (0,9 to 1,8 g/kg). This dose is diluted 1:1 (i.e., 35% solution) for children (44).

Indications

Cathartics have never been shown to improve morbidity and mortality or to decrease hospital stay (45). They decrease the constipating effects of charcoal and are now only used as an adjunct to activated charcoal to speed up gastrointestinal motility and reduce the transit time of charcoal, particularly when drugs with constipating effects have been ingested (46), thereby decreasing the risks of intestinal obstruction and desorption of toxins.

Adverse reactions and contraindications

Common undesirable effects of cathartics include abdominal cramps, excessive diarrhea, and abdominal distension. Dehydration and electrolyte imbalance can occur, especially in children when repeated doses of cathartics are administered (47). Repeated dosage of magnesium-containing cathartics may result in hypermagnesemia and magnesium toxicity (48-51). Contraindications to the use of cathartics include the ingestion of corrosives, severe diarrhea, electrolyte imbalance, and recent bowel surgery. Cathartics should be used with caution when bowel sounds are absent (2,52).

Whole-bowel irrigation

Whole bowel irrigation is a method to rapidly and mechanically wash the entire gastrointestinal tract. It is very similar to the method commonly used by gastroenterologists to prepare patients for colonic investigations or surgery and which has been proved efficacious and safe, even in children, pregnant women or subjects with cardiac or respiratory failure provided adequate cleansing solution are used. The use of PEG-ELS solution in WBI produces no significant changes in serum electrolytes, serum osmolality, body weight, or hematocrit (53). Both PEG-3350 and sulfate ions are poorly absorbed from the gastrointestinal tract, even in the presence of inflammatory bowel disease (54). The divalent sulfate ion impairs the active transport of sodium, and PEG-3350 prevents the shift of fluid across the intestinal wall by restoring the isotonicity of the solution.

The technique consists of passing a nasogastric tube into the stomach and continuously administering a non absorbable high-molecular-weight polyethylene glycol (PEG-3350) — isotonic electrolyte solution (PEG-ELS) at a rate of 2 L/h (500 mL/h for pediatric patients under 12 years of age — 25-40 mL/kg). The endpoint consist of recovery of toxins or clear rectal effluent clear, similar in appearance to the infusate. The usual infusion lasts 2 to 6 hours (55). This does not ensure that the toxin is eliminated. Alternatively, the solution can be ingested orally, but an adequate rate of fluid ingestion is rarely obtained, especially in patients with low compliance to the treatment. Disadvantages include patient handling and collection/disposal of the effluent which requires an intensive nurse labor, especially in patients with impairement of consciousness who are not able to sit on a commode.

Nausea and vomiting may be prevented by systematic administation of antiemetic agents as intravenous metoclopramide (10 mg adults, 0.1-0.3 mg/kg body weight. Activated charcoal does adsorb powdered PEG. The concurrent administration of multiple doses of charcoal does not improve the effectiveness of WBI (56); however, in vitro data do not exclude the effectiveness of an initial dose of activated charcoal prior to the initiation of WBI (57).

Indications

WBI does not increase the clearance of a drug already aborbed (58), but is probably a useful method to empty the GI tract in 4 to 6 hours. Potential clinical indications in toxicology include ingestion of massive amounts of highly toxic drugs; especially in patients who present late (> 4 hours after ingestion) (59), large overdoses of sustained-release preparations (e.g., theophylline, verapamil) (60). Poisonings with these preparations have demonstrated multiple peak concentrations indicating continuing and variable absorption for more than 24 hours (28). Other indications of WBI may include ingestion or colonic concealment of packets of illicit drug by body packers (61,62); or ingestion of substances not adsorbed by activated charcoal (e.g., iron, lithium, potassium). WBI has especially been shown safe and effective decontamination procedure for potentially lethal iron ingestions, especially if the iron tablets have passed the pylorus (63). WBI has also been used in ingestion of toxic substances that can be detected by radiography (arsenic, carbon tetrachloride, mercury, thallium, lead) (64,65). WBI effectively fasten removal of miniature button batteries from the gut, but the procedure is usually considered unnecessary (66).

Although potential indications of this procedure are numerous, there is little evidence to indicate a decreaded morbidity or mortality from this decontamination technique.

Adverse effects and contraindications

Few complications occur following the use of WBI for preparation of the bowel for radiographic examination or for surgery in either adults or children (67) even in the presence of cardiac, renal, or pulmonary disease (68). Complaints usually are minor and include nausea, vomiting, abdominal distension and cramps, and anal irritation (69). Contraindications to the use of WBI include gastrointestinal pathology or dysfunction (obstruction, ileus, hemorrhage, perforation) and inadequate airway protection.

Conclusion

Gastric emptying procedures in the Emergency Department are usually ineffective, may result in increased

morbidity, and appear to offer no clinical advantage over administration of activated charcoal alone. They have been largely abandonned as routine procedures.

Early ardministration of adequate amounts of activated charcoal is appropriate in the majority of case, either orally or through a small-bore nasogastric tube in obtunded patients. It is contraindicated after ingestion of hydrocarbons or corrosives. A few substances are not adsorbed by charcoal. Sorbitol may be used to prevent constipation when multiple doses of charcoal are administered.

Whole bowel indication may be a useful technique for specific indications.

Finally, in many patients, a "do nothing approach" may appear justified provided the history suggesting a low risk situation appears reliable.

References

1. LHEUREUX P., ASKENASI R. Prévention de l'absorption digestive des toxiques : une réévaluationcritique. Première partie : l'évacuation du contenu gastrique. *Réan. Urg.*, 1993, **1** : 751-759.
2. LHEUREUX P., ASKENASI R. Prévention de l'absorption digestive des toxiques : une réévaluation critique. Deuxième partie : utilisation du charbon activé et des laxatifs. *Réan. Urg.*, 1993, **1** : 915-926.
3. Conférence de Consensus en Réanimation. Epuration digestive lors des intoxications aiguës. *Réan. Urg.*, 1993, **2** : 169-242.
4. LOVEJOY F.H. JR., SHANNON M., WOOLF A.D. Recent advances in clinical toxicology. *Curr. Problems Pediatr.*, 1992 : 119-129.
5. AACT and EAPCCT Position Statment on gastrointestinal decontamination procedures. *J. Toxicol. Clin. Toxicol.*, 1998 (in press).
6. VANCE M.V., SELDEN B.S., CLARK R.F. Optimal patient position for transport and initial management of toxic ingestions. *Ann. Emerg. Med.*, 1992, **21** : 243-246.
7. ARNOLD F.J., HODGES J.B., BARA R.A. Evaluation of the efficacy of lavage and induced emesis in treatment of salicylate poisoning. *Pediatrics*, 1959, **23** : 286-301.
8. ABDALLAH A.H., TYE A. A comparison of the efficacy of emetic drugs and stomach lavage. *Am. J. Dis. Child.*, 1967, **113** : 571-574.
9. CORBY D.G., LISCIANDRO R.C., LEHMAN R.G. *et al.* The efficacy of methods used to evacuate the stomach after acute ingestions. *Pediatrics*, 1967, **40** : 871-874.
10. TANDBERG D., DIVEN B.G., McLEOD J.W. Ipecac-induced emesis versus gastric lavage : A controlled study in normal adults. *Am. J. Emerg. Med.*, 1986, **4** : 205-209.
11. LITOVITZ T.L. Emesis versus lavage for poisoning victims. *Am. J. Emerg. Med.*, 1986, **4** : 294-295.
12. JAWARY D., CAMERON P.A., DZIUKAS L., McNEIL J.J. Drug overdose : Reducing the load. *Med. J. Aust.*, 1992, **156** : 343-436.
13. LHEUREUX P. Induction of Emesis. WHO/IPCS Monographs on the management of acute toxic exposures, 1995.
14. McGUIGAN M., KRENZELOK E.P., LHEUREUX P. AACT and EAPCCT Position Statment : Syrup of ipecac. *J. Toxicol. Clin. Toxicol.*, 1998 (in press).
15. WRENN K., RODEWALD L., DOCKSTADER L. Potential misuse of ipecac. *Ann. Emerg. Med.*, 1993, **22** : 1408-1412.
16. SAINCHER A., SITAR D., TENENBEIN M. Efficacy of ipecac during the first hour after drug ingestion in human volunteers. *J. Toxicol. Clin. Toxicol.*, 1997, **35** : 609-615.
17. VALE J.A., MEREDITH T.J., PROUDFOOT A.T. Syrup of ipecacuanha : is it really useful ? *Br. Med. J.*, 1986, **293** : 1321-1322.
18. KORNBERG A.E., DOLGIN J. Pediatric ingestions : Charcoal alone versus ipecac and charcoal. *Ann. Emerg. Med.*, 1991, **20** : 648-651.
19. VALE A. AACT and EAPCCT Position Statment : gastric lavage. *J. Toxicol. Clin. Toxicol.*, 1998 (in press).
20. BURKE M. Gastric lavage and emesis in the treatment of ingested poisons : A review and a clinical study of lavage in ten adults. *Resuscitation*, 1972, **1** : 91-105.
21. AUERBACH P.S., OSTERLOH J., BRAUN O. *et al.* Efficacy of gastric emptying : Gastric lavage versus emesis induced with ipecac. *Ann. Emerg. Med.*, 1986, **55** : 692-698.
22. DANEL V., HENRY J.A., GLUCKSMAN E. Activated charcoal, emesis, and gastric lavage in aspirin overdose. *Br. Med. J.*, 1988, **296** : 1507.
23. TENENBEIN M., COHEN S., SITAR D.S. Efficacy of ipecac-induced emesis, orogastric lavage, and activated charcoal for acute drug overdose. *Ann. Emerg. Med.*, 1987, **16** : 838-841.
24. KULIG K., BAR-OR D., CANTRILL J.V. *et al.* Management of acutely poisoned patients without gastric emptying. *Ann. Emerg. Med.*, 1984, **14** : 562-567.
25. WATSON W.A., LEIGHTON J., GUY J. *et al.* Recovery of cyclic antidepressants with gastric lavage. *J. Emerg. Med.*, 1989, **7** : 373-377.
26. COMSTOCK E.G., BOISAUBIN E.V., COMSTOCK B.S. *et al.* Assessment of the efficacy of activated charcoal following gastric lavage in acute drug emergencies. *J. Toxicol. Clin. Toxicol.*, 1982-1983, **19** : 149-165.
27. HODGKINSON D.W., JELLETT L.B., ASHBY R.H. A review of the management of oral drug overdose in the accident and emergency department of the Royal Brisbane Hospital. *Arch. Emerg. Med.*, 1991, **8** : 8-16.
28. BUCKLEY N.A., DAWSON A.H., REITZ D.A. Controlled release drugs in overdose : Clinical considerations. *Drug Saf.*, 1995, **12** : 73-86.
29. ALBERTSON T.E., DERLET R.W., FOULKE G.E. *et al.* Superiority of activated charcoal alone compared with ipecac and activated charcoal in the treatment of acute toxic ingestions. *Ann. Emerg. Med.*, 1989, **18** : 101-104.
30. MERIGIAN K.S., WOODARD M., HEDGES J.R. *et al.* Prospective evaluation of gastric emptying in the self-poisoned patient. *Am. J. Emerg. Med.*, 1990, **8** : 479-483.
31. SAETTA J.P., MARSH S., GAUNT M.E., QUINTON D.N. Gastric emptying procedures in the self-poisoning patients : Are we forcing gastric content beyond the pylorus ? *J. R. Soc. Med.*, 1991, **84** : 274-276.
32. SAETTA J.P., QUINTON D.N. Residual gastric content after gastric lavage and ipecacuanha-induced emesis in self-poisoned patients : An endoscopic study. *J. R. Soc. Med.*, 1991, **84** : 35-38.
33. OLSON K.R. Is gut emptying all washed up ? *Am. J. Emerg. Med.*, 1990, **8** : 560-561. Editorial.
34. PALATNICK W., TENENBEIN M. Activated charcoal in the treatment of drug overdose : An update. *Drug Saf.*, 1992, **7** : 3-7.
35. KULIG K. Initial management of ingestions of toxic substances. *N. Engl. J. Med.*, 1992, **326** : 1677-1681.
36. LINDEN C. Activated charcoal. *Clin. Toxicol. Rev.*, 1987, **9** : 1-2.
37. VALE A. AACT and EAPCCT Position Statment : activated charcoal. *J. Toxicol. Clin. Toxicol.*, 1998 (in press).
38. ATKINSON S.W., YOUNG Y., TROTTER G.A. Treatment with activated charcoal complicated by gastrointestinal obstruction requiring surgery. *Br. Med. J.*, 1992, **305** : 563.
39. FLORES F., BATTLE W.S. Intestinal obstruction secondary to activated charcoal. *Con. Surg.*, 1987, **30** : 57-59.
40. WATSON W.A., CREMER K.F., CHAPMAN J.A. Gastrointestinal obstruction associated with multiple-dose activated charcoal. *J. Emerg. Med.*, 1986, **4** : 401-407.
41. HARVEY R.F., READ A.E. Mode of action of the saline purgatives. *Am. Heart J.*, 1975, **89** : 810-813.
42. COOKE A.R. Control of gastric emptying and motility. *Gastroenterology*, 1975, **68** : 804-816.
43. KRENZELOK E.P., KELLER R., STEWART R.D. Gastrointestinal transit times of cathartics combined with charcoal. *Ann. Emerg. Med.*, 1985, **14** : 1152-1155.
44. MINOCHA A., KRENZELOK E.P., SPYKER D.A. Dosage recommendations for sorbitol-charcoal treatment. *Clin. Toxicol.*, 1985, **23** : 579-587.
45. RIEGAL J.M., BECKER C.E. Use of cathartics in toxic ingestions. *Ann. Emerg. Med.*, 1981, **10** : 254-258.
46. HARCHELROAD F., COTTINGTON E., KRENZELOK E.P. Gastrointestinal transit times of a charcoal/sorbitol slurry in overdose patients. *Clin. Toxicol.*, 1989, **27** : 91-99.
47. ALLERTON J.P., STROM J.A. Hypernatremia due to repeated doses of charcoal-sorbitol. *Am. J. Kidney Dis.*, 1991, **17** : 581-584.
48. MOFENSON H.C., CARACCIO T.R. Magnesium intoxication in a neonate from oral magnesium hydroxide laxative. *Clin. Toxicol.*, 1991, **29** : 215-222.
49. JONES J., HEISELMAN D., DOUGHERTY J., EDDY A. Cathartic induced magnesium toxicity during overdose management. *Ann. Emerg. Med.*, 1986, **15** : 1214-1218.
50. SMILKSTEIN M.J., SMOLINSKE S.C., KULIG K.W., RUMACK B.H. Severe hypermagnesemia due to multiple dose cathartic therapy. *West J. Med.*, 1988, **148** : 208-211.
51. WOODARD J.A., SHANNON M., LACOUTURE P.G., WOOLF A. Serum magnesium concentrations after repetitive magnesium cathartic administration. *Am. J. Emerg. Med.*, 1990, **8** : 297-300.
52. BARCELOUX D., MCGUIGAN M., HARTIGAN-GO K. AACT and

EAPCCT Position Statment : Cathartics. *J. Toxicol. Clin. Toxicol.*, 1998 (in press).
53. TENENBEIN M., COHEN S., SITAR D. Whole bowel irrigation as a decontamination procedure after acute drug overdose. *Arch. Intern Med.*, 1987, **147** : 905-907.
54. BRADY C.E. III, DIPALMA J.A., MORAWSKI S.G. *et al.* Urinary excretion of polyethylene glycol 3350 and sulfate after gut lavage with a polyethylene glycol electrolyte lavage solution. *Gastroenterology*, 1986, **90** : 1914-1918.
55. TENNENBEIN M. AACT and EAPCCT Position Statment : Whole bowel irrigation. *J. Toxicol. Clin. Toxicol.*, 1998 (in press).
56. HOFFMAN R.S., CHIANG W.K., HOWLAND M.A. *et al.* Theophylline desorption from activated charcoal caused by whole bowel irrigation solution. *J. Toxicol. Clin. Toxicol.*, 1991, **29** : 191-201.
57. KIRSHENBAUM L.A., SITAR D.S., TENENBEIN M. Interaction between whole-bowel irrigation solution and activated charcoal : Implications for the treatment of toxic ingestions. *Ann. Emerg. Med.*, 1990, **19** : 1129-1132.
58. MAYER A.L., SITAR D.S., TENENBEIN M. Multiple-dose charcoal and whole-bowel irrigation do not increase clearance of absorbed salicylate. *Arch. Intern Med.*, 1992, **152** : 393-396.
59. TENENBEIN M. Whole bowel irrigation as a gastrointestinal decontamination procedure after acute poisoning. *Med. Toxicol.*, 1988, **3** : 77-84.
60. KIRSHENBAUM L.A., MATHEWS S.C., SITAR D.S., TENENBEIN M. Whole-bowel irrigation versus activated charcoal in sorbitol for the ingestion of modified-release pharmaceuticals. *Clin. Pharmacol. Ther.*, 1989, **46** : 264-271.
61. HOFFMAN R.S., SMILKSTEIN M.R., GOLDFRANK L.R. Whole bowel irrigation and the cocaine body-packer : A new approach to a common problem. *Am. J. Emerg. Med.*, 1990, **8** : 523-527.
62. TENENBEIN M. Whole bowel irrigation for toxic ingestions. *Clin. Toxicol.*, 1985, **23** : 177-184.
63. TENENBEIN M. Whole bowel irrigation in iron poisoning. *J. Pediatr.*, 1987, **111** : 142-145.
64. BOBA A. Whole bowel irrigation. *Am. J. Emerg. Med.*, 1994, **12** : 257.
65. ROBERGE R.J., MARTIN T.G. Whole bowel irrigation in an acute oral lead intoxication. *Am. J. Emerg. Med.*, 1992, **10** : 577-583.
66. LHEUREUX P., CAVENAILE J.C., CORNIL A., NOUVELLE M., SERMON F., LEDUC D., R ASKENASI R. Ingestion de corps étrangers : Attitude pratique. *Réan. Urg.*, 1996, **5** : 637-653.
67. SONDHEIMER J.M., SOKOL R.J., TAYLOR S.F. *et al.* Safety, efficacy, and tolerance of intestinal lavage in pediatric patients undergoing diagnostic colonoscopy. *J. Pediatr.*, 1991, **110** : 148-152.
68. GOLDMAN J., REICHELDERFER M. Evaluation of a rapid colonoscopy preparation using a new gut lavage solution. *Gastrointest. Endosc.*, 1982, **28** : 9-11.
69. DIPALMA J.A., BRADY C.E. Colon cleansing for diagnostic and surgical procedures : Polyethylene glycol-electrolyte lavage solution. *Am. J. Gastroenterol.*, 1989, **84** : 1008-1016.