# The "two bag system" for variable intravenous dextrose and fluid administration: Benefits in diabetic ketoacidosis management

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A case-controlled retrospective analysis compared the "two bag system," based on the euglycemic clamp technique, versus the traditional "one bag" method for intravenous diabetic ketoacidosis management. The two bag system can provide more cost-effective intravenous dextrose and fluid delivery and enhance quality of care by improving the efficiency, timeliness, and flexibility of overall control. (J Pediatr 1999;134:376-8)

Frequent modifications in intravenous therapy are required during the treatment of patients with diabetic ketoacidosis to adapt to fluctuations in the fluid, electrolyte, and dextrose needs of the patient.[1-3] Traditionally, on initiation of IV insulin therapy, one bag of IV electrolyte and dextrose solution, determined by the patient's presenting clinical requirements, is prepared and hung; as blood glucose levels fall as a result of the ongoing insulin action, a new bag with the appropriately altered glucose content must be ordered from the pharmacy and then when ready, replace the previous bag even if it was not completely consumed. Multiple sequential fluid bag changes may follow the course of therapy. Several limitations of the traditional approach, hereafter referred to as the "one bag system," are easily apparent: restricted variations, slow response time, and increased cost. In 1994 a new method of IV fluid therapy called the "two bag system" was introduced at the Children's Hospital of Philadelphia to address the aforementioned problems. This study reviews the design of the two bag system and in a case-controlled retrospective manner evaluates its efficacy at surmounting the shortcomings of the traditional one bag system.

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## METHODS

### *The Two Bag System Design*

The two bag system, an adaptation of euglycemic clamp experiment techniques,[4,5] consists of 2 bags of identical electrolyte content but different dextrose concentration (0% and 10%) administered simultaneously into a single IV line. Variations in dextrose delivery are achieved through differential proportions of the 2 bags contributing to the total rate, which is determined by the patient's degree of dehydration (Figure, *A*). A typical clinical course with the two bag system is exemplified in the Figure, *B* and *C*. As evident in the Figure, IV glucose administration is adjusted to control the rate of blood glucose decline and to prevent hypoglycemia from developing despite the continued insulin requirement. By titrating the differential proportions of the 2 bags, the amount of glucose administration and the total fluid rate can be manipulated independently, as can the insulin infusion dose.

| | |
|---|---|
| DKA | Diabetic ketoacidosis |
| IV | Intravenous |

### *Patient Characteristics*

Since the two bag system was introduced at our institution in 1994, DKA admissions from 1993 to 1995 were reviewed. Ten patients treated by the two bag system and 10 by the one bag system were chosen by initial venous pH (<7.2) and length of intensive care unit stay (10 to 36 hours) and were subsequently matched for age, weight, and duration of IV therapy (Table). Selection of the IV system was made by the treating medical team, consisting of 4 attendings, 1 fellow, and rotating housestaff, based temporally on our institutional switch in IV systems.

In fact, 12 patients had repeated DKA admissions, and 4 of these were treated by both methods. Initial resuscitation protocols and insulin regimens were not changed. Matching by body size and severity of illness controlled 2 major variables affecting overall fluid requirement.

### *Data Collection and Analysis*

The patients' medical charts were retrospectively reviewed, and the total number of IV bags used per patient, the corresponding cost of IV therapy, and the time delays for IV changes were tabulated. Because of variance in The Children's Hospital of Philadelphia billing parameters between 1993 and 1995, all costs were adjusted for the current Children's Hospital of Philadelphia pharmacy fees ($127 per liter bag of standard IV solution). Our analysis addresses the cost solely of the IV electrolyte and dextrose solutions and not that accrued for other pharmaceuticals such as insulin or nonpharmaceutical hospitalization fees. The response time was calculated by the difference between the recorded time of the written physician orders and the recorded time of the implemented changes by the nursing staff. Values for the two bag system were compared with those of the one bag system by both the unpaired *t* test and the Mann-Whitney test.

## RESULTS

As shown in the Table, the two bag system significantly decreased the number of IV bags used per admission, thereby incurring a significantly lower IV therapy cost. Response time for IV fluid changes was even more dramatically reduced, from more than ½ hour with the one bag system to <10 minutes with the two bag system. All patients reviewed for this study underwent full correction of their DKA state without any complications including cerebral edema.

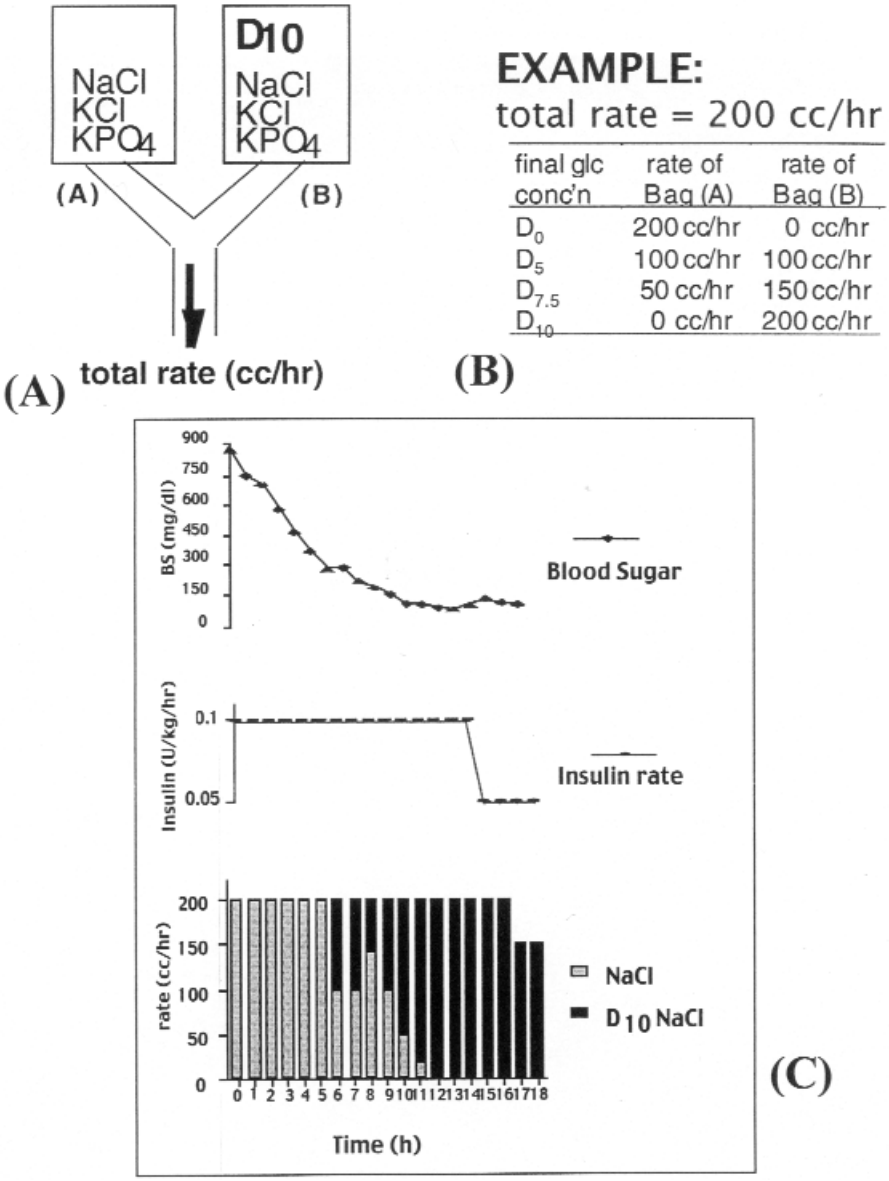


***Figure.*** Schematic of two bag system and illustrative typical course. **A,** Two bag system allows independent manipulation of glucose and total fluid volume, because electrolyte content of 2 bags is identical except for dextrose. **B,** Differential rates of 2 bags modulates glucose delivery, which can be any concentration ranging from 0% to 10%. Total fluid volume is based on patient's degree of dehydration and ongoing fluid requirement. **C,** In this typical course, insulin therapy is instituted as continuous infusion of 0.1 U/kg/h, and total fluid rate is set at 200 cc/h. Because patient is markedly hyperglycemic, no dextrose is given initially. As insulin action lowers patient's blood glucose level, dextrose is titrated into IV fluid without changing administered fluid volume. Glucose titration aims to control rate of blood glucose decline (possible risk factor for cerebral edema) and prevent hypoglycemia in the face of continued insulin requirement. Later on, when patient's dehydration and ketosis become partially corrected, insulin and total fluid can also be independently adjusted.

## DISCUSSION

The two bag system for variable dextrose and fluid administration in DKA management effectively addresses the limitations of the traditional one bag system: restricted variations, slow response time, and increased cost. From our experience and as exemplified in the Figure, *B*, the two bag system enables independent manipulation of total fluid, electrolyte, dextrose, and insulin administration, allowing the physician to more precisely tailor the

***Table.*** Comparison of the one bag and two bag systems

| | One bag system | Two bag system | Unpaired *t* test | Mann-Whitney test |
|---|---|---|---|---|
| Patient characteristics | | | | |
| No. of patients | 10 | 10 | NS | NS |
| Age (y) | 12.0 ± 2.0 | 13.5 ± 2.2 | NS | NS |
| Weight (kg) | 38.4 ± 9.9 | 48.5 ± 13.3 | NS | NS |
| Sex | 6 F; 4 M | 8 F; 2 M | — | — |
| DKA as initial presentation of IDDM | 4 | 4 | NS | NS |
| Initial venous pH | 7.11 ± 0.07 | 7.06 ± 0.10 | NS | NS |
| Duration of IV therapy (h) | 17.8 ± 7.5 | 16.6 ± 5.0 | NS | NS |
| Results | | | | |
| No. of IV bags used per admission | 8.6 ± 1.2 | 4.8 ± 0.3 | $P = .01$ | $P = .0001$ |
| Cost of IV fluid therapy ($) | 1092 ± 147 | 622 ± 40 | $P = .01$ | $P = .0003$ |
| Response time for IV fluid changes (min) | 36.7 ± 1.4 | 7.4 ± 1.1 | $P < .0001$ | $P < .0001$ |

Values are reported as mean ± SEM. None of the patient characteristics differed significantly. The two bag system, however, required fewer IV bags, incurred a lower cost, and reduced response time for IV fluid changes.
*IDDM,* Insulin-dependent diabetes mellitus.

IV therapy to the individual patient's evolving needs. The two bag system can deliver virtually any dextrose concentration on the continuous gradient from 0% through 10%. Thus by titrating the proportional rates of the 2 bags, the physician can also easily provide nonstandard dextrose concentrations, if that seems necessary to better fine-tune the therapy for any given patient.

Whenever a change in IV fluid therapy is warranted, the two bag system can also reduce the delay between the time of physician order to its implementation from, on average, more than ½ hour to <10 minutes. In fact, the physician need only identify the patient's nurse and adjust the respective rates on the IV pumps, making alterations virtually immediate. This accelerated responsiveness combined with the enhanced flexibility described previously empowers the physician to provide more timely, frequent, incremental adjustments in dextrose and fluid administration and thus keep pace with the patient's rapidly evolving metabolic demands.

In addition to its clinical advantages, the two bag system is also economically sound. According to current billing parameters the two bag system costs on average approximately $500 less per DKA admission than the one bag system. This saving is achieved by reducing the number of IV solution bags required to implement the necessary modulations in IV fluid therapy throughout the course of DKA correction. We estimate that in our hospital alone, we save >$75,000 per year with this system, and the potential savings nationwide are immense.

Thus we conclude that the two bag system for variable IV dextrose and fluid delivery as applied to DKA management can enhance the quality of care in terms of augmented efficiency, timeliness, and flexibility of overall control while also improving its cost-effectiveness. We have found the two bag system similarly beneficial in other clinical settings requiring frequently fluctuating dextrose and fluid administration, such as the immediate postoperative period after subtotal pancreatectomy in patients with congenital hyperinsulinism.

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