A COST COMPARISON OF TWO SYSTEMS FOR THE INTERMITTENT INTRAVENOUS ADMINISTRATION OF SMALL VOLUME PARENTERALS

by

Robert Thomas Reilly

A project submitted to the faculty of the
University of Utah in partial fulfillment of the requirements
for the degree of

Doctor of Pharmacy

College of Pharmacy

University of Utah

June 1984

UNIVERSITY OF UTAH COLLEGE OF PHARMACY

FINAL READING APPROVAL

TO THE DOCTOR OF PHARMACY COMMITTEE OF THE UNIVERSITY OF UTAH COLLEGE OF PHARMACY:

I have read the clinical research project report of Robert Thomas Reilly in its final form and have found that 1) its format, citations, and bibliographic style are consistent and acceptable; 2) its illustrative materials including figures, tables, and charts are in place; and 3) the final manuscript is satisfactory to the Supervisory Committee and is ready for submission to the Doctor of Pharmacy Committee.

23 May 84
Date

Chairman, Supervisory Committee

Approved for the Department of Pharmacy Practice

Chairman

Approved for the Doctor of Pharmacy Committee

Chairman, Doctor of Pharmacy Committee

UNIVERSITY OF UTAH COLLEGE OF PHARMACY

SUPERVISORY COMMITTEE APPROVAL

of a clinical research project report submitted by

Robert Thomas Reilly

We, the undersigned, have read this clinical research project report and have found it to be of satisfactory quality for a Doctor of Pharmacy Degree.

17 May 84
Date

Chairman, Supervisory Committee

17 May 84
Date

Member, Supervisory Committee

17 May 84
Date

Member, Supervisory Committee

ACKNOWLEDGEMENTS

I wish to express my sincerest appreciation and gratitude to the members of my Supervisory Committee, Jean Devenport, Linda Strand, and Jan Bair, for their continued support and patience in the preparation of this manuscript. Also, to Art Lipman for his comments and insight, Ross Woolley for his assistance with computer analysis of the data, Allyson Biggs and Kathy McCoun for their assistance with data collection, Jeff Richardson for his assistance in computer coding the data, the personnel of the centralized Intravenous Admixture Service for this cooperation and understanding, and Aloma Kern for her typing of this manuscript.

A very special thanks goes to my fellow classmates and residents whose support and criticisms have been invaluable over the past two years. We have all endured the joys, trials and tribulations of obtaining the Doctor of Pharmacy degree, and now we know, with painful insight, the truth of that famous saying, "Pharm.D.'s do it on the run!" So, until our paths cross again, take care my friends.

TABLE OF CONTENTS

LIST OF ILLUSTRATIONS

INTRODUCTION

The decision-making processes of a hospital pharmacy administrator include the determination of the most advantageous means by which intravenously administered drugs may be prepared and distributed. Systems to accomplish this have become increasingly more efficient, less hazardous to the patient, but more costly to the Department of Pharmacy Services.[1-4] These increases in costs have been passed on to the patient, and subsequently to third party payers of health care services. One such system is the piggyback bottle system, which is currently in use at University Hospital.

The introduction of the prospective payment system by several third party payers of health care services will require hospital pharmacy administrators to evaluate and justify the cost of preparing and distributing intravenously administered drugs. A system which purportedly has the same advantages as those of the piggyback bottle system, but at a reduced cost to the Department of Pharmacy Services, is the Harvard® Mini-Infuser System. A comparative study of the two systems was performed to determine actual cost savings at University Hospital.

OBJECTIVE

The objective of this study was to determine the comparative personnel and material acquisition costs to the Department of Pharmacy Services at University Hospital of two systems for the intermittent intravenous administration of drugs.

DESCRIPTION OF THE SYSTEMS

The two systems involved were the piggyback bottle system and the proposed syringe infusion system, the Harvard® Mini-Infuser System.

The piggyback bottle system is illustrated in Figure 1. A primary intravenous solution container delivers solution to the patient via a primary infusion set and extension set. The primary infusion set contains a one-way valve, roller clamp, and a Y-injection site. A secondary piggyback set, with a roller clamp, is connected to this Y-injection site. The piggyback bottle containing the drug for intravenous infusion is attached to the secondary piggyback set by inserting the spiked end of the secondary piggyback set into the piggyback bottle. The intravenous drug solution is gravity-delivered, with the rate of delivery determined by the roller clamp on the secondary piggyback set or by the roller clamp on the primary infusion set.

Variations of this system may be used at other hospitals. A minibag may be substituted for the piggyback bottle. Also, a primary infusion solution may not be used, and the piggyback bottle, or minibag, may be infused directly into a peripheral vein via an intermittent infusion set (heparin lock).

The syringe infusion system is illustrated in Figure 2. This system consists of a syringe, an administration set, and an infusion pump. The syringe is a plastic, calibrated, disposable syringe that may vary in size from 3 to 60 milliliters. The variation in size depends on the stability and dilutional requirements of the drug to be administered.

A primary intravenous solution container delivers solution to the patient via a primary infusion set and extension set. The primary

infusion set incorporates neither a one-way valve nor a Y-injection site. However, to the Y-injection site on the extension set is connected the administration, or secondary microbore set. This secondary microbore set is a disposable, microbore tubing (manufactured by C.R. Bard, Inc.) that resists kinking, requires minimal fluid for priming, and attaches to the syringe via a winged luer lock fitting. A variation of this part of the system may be used at other hospitals. The primary infusion container, primary infusion set and extension set may not be used. Instead, the secondary microbore set, with a needle attached, may be connected directly to an intermittent infusion set (heparin lock).

The drug-containing syringe, with the attached secondary microbore set, is placed in the syringe holder of the infusion pump. The infusion pump is a battery operated, single speed syringe infusion pump. It is designed for accurate, controlled, infusion of drugs that are to be administered by intermittent intravenous infusion in 40 minutes or less. The pump has audible and visual alarms to indicate the end of an infusion in progress, or low battery power. The pump will alarm and automatically shut off at the end of an infusion or an occlusion (four to eight pounds per square inch occlusion force, depending on model of pump).[5]

METHODS

This investigation was conducted as a prospective, comparative study of the current piggyback bottle system in use at University Hospital and the Harvard® Mini-Infuser System. The piggyback bottle system provided the baseline data, and the Harvard system the

comparative study data. Personnel and material acquisition costs were determined for each system.

Personnel Costs

Baseline data collection consisted of identifying, as measurable units, the activities involved in the preparation of drug doses into piggyback bottles by the pharmacists of the centralized Intravenous Admixture Service (Appendix). Once identified, these activities were observed, timed, and recorded for a 14-day period, using the continuous stopwatch technique as described by Miller et al,[2] for all orders of small volume parenterals. The total number of doses prepared was recorded.

A general surgical unit consisting of 32 beds was selected as the study unit. Characteristics of the unit which made it desirable for study included its size, the number of small volume parenterals ordered and the enthusiasm and cooperation of the nursing personnel. A four week education and orientation period followed baseline data collection. During this time period, pharmacy and nursing personnel servicing this patient care unit familiarized themselves with the procedures involved in utilizing the Harvard® system.

At the end of the four week period, pharmacists of the centralized Intravenous Admixture Service had achieved a consistent level of efficiency and study data were collected for the Harvard® system. The activities involved in the preparation of drug doses for the Harvard® system by the pharmacists of the centralized Intravenous Admixture Service were identified as measurable units in the same manner as was done for the piggyback bottle system (Appendix). The data were collected for a 14-day period in the same manner as was done for the

piggyback bottle system for all orders of small volume parenterals. The total number of doses prepared was recorded.

When compared, the only activities performed differently for the two systems were stocking and retrieval, transferring, and labeling of the drugs (Appendix). These steps were then used to determine the difference in preparation time between the two systems by comparing those drugs prepared in both systems. The average salary of the pharmacists of the centralized Intravenous Admixture Service was then applied to the preparation times to determine the difference in personnel costs of the two systems.

Material Acquisition Costs

The materials used in the preparation of small volume parenterals for the piggyback bottle system and the Harvard® system were observed, recorded, and itemized according to fixed and variable costs. Fixed costs related to those items for which the cost per dose would not vary with the number of doses prepared. Variable costs related to those items for which the cost per dose would vary according to how many doses were used per item. The actual hospital acquisition costs of the materials used at University Hospital were then determined. The cost of transfer needles was determined as an average cost per dose. This cost was determined in this manner as not all doses utilized a transfer needle, but this cost was unique to the piggyback bottle system and was included as a fixed cost for that system. Minimal costs common to both systems (alcohol swabs, etc.) were not considered for the purpose of this comparative analysis.

The annualized purchases for calendar 1983 were determined for piggyback bottles, primary infusion sets (adult and pediatric) and secondary piggyback sets. From these data the following were determined: 1) the percent of adult primary infusion sets used; 2) the number of piggyback bottles used for adult doses; 3) the number of secondary piggyback sets used for adult doses; 4) the number of primary infusion sets used per adult dose; and 5) the number of secondary piggyback sets used per adult dose. Only adult piggyback bottle doses were considered for conversion to the Harvard® system.

A basic assumption of hospital pharmacy management at University Hospital was that approximately 80 percent of adult piggyback bottle doses could be converted to the Harvard® system. This percentage was based on the number of drugs for which the dilutional and administration requirements allowed the intermittent intravenous infusion of the small volumes necessary to utilize the Harvard® system. This assumption, along with the data derived from the annualized purchases for calendar 1983 and the fixed and variable costs, were used to calculate the total costs for the implementation year and second year for both systems. Costs were calculated for the varying number of doses (from 1 to 8) that could be given per Harvard® secondary microbore sets. These data were compared to current cost data of the piggyback bottle system for the same time period and provided information to determine the dose-to-secondary microbore set ratio which would make the Harvard® system cost-effective. This dose-to-secondary microbore set ratio was used in the final cost analysis of the two systems. No future provider price increases were taken into account for either system.

Syringe infusion pumps for the Harvard® system could be purchased by contract agreement, either in conjunction with, or separately from, a specified number of case purchases of secondary microbore sets. With the former option, the cost of the secondary microbore sets would reflect the purchase of the syringe infusion pumps and would cost more than if no syringe infusion pumps were included with case purchases. Hospital pharmacy management decided that the number of syringe infusion pumps needed at University Hospital could best be purchased utilizing the option of purchasing a specified number of cases of secondary microbore sets, at the higher cost, for the first year of use of the Harvard® system.

RESULTS

Personnel Costs

The time involved for the activities of stocking and retrieval, transferring, and the labeling of drugs were determined for the following drugs which were prepared in both systems: cefazolin sodium, cefoxitin sodium, cephapirin sodium, cimetidine, clindamycin phosphate, gentamicin sulfate, nafcillin sodium, and penicillin G potassium. All dosages ordered for each drug were included. The mean (± standard deviation) time per dose for all activities listed in the Appendix was 15.7 ± 27.4 seconds for the piggyback bottle system and 17.5 ± 20.6 seconds for the Harvard® system. The mean (± standard deviation) time involved for those activities that were performed differently between the two systems are presented in Table 1. Each activity took more time to perform in the Harvard® system. Transferring of the drug to the final container (syringe) took the most time.

However, the difference in the time required for preparation was approximately two seconds. When the average salary for the centralized Intravenous Admixture Service pharmacists was applied to this difference, only minimal cost difference for personnel could be demonstrated between the two systems (approximately $0.012 per dose, or $811.10 per 67,592 doses).

Material Acquisition Costs

Fixed and variable costs, as previously defined, for each system are presented in Table 2. The fixed costs per dose were less for the Harvard® system ($0.196) compared to the piggyback bottle system ($0.850). The variable costs per dose were less for the piggyback bottle system ($2.516) compared to the Harvard® system ($4.093), during the implementation year. However, the variable costs per dose were similar for the two systems during the second year ($2.516 compared to $2.520).

The annualized purchases for calendar 1983 and the usage analysis from these purchases were determined. One adult primary infusion set was used for at least four piggyback bottle doses. One secondary piggyback set was used for each adult piggyback bottle dose. Eighty percent conversion of adult piggyback bottle doses to syringe doses would result in 67,592 syringe doses for use with the Harvard® system. The dose-to-secondary microbore set ratio for the Harvard® system was calculated for one to eight doses per secondary microbore set. The dose-to-secondary microbore set ratio for cost-effectiveness was 4-to-1 to 5-to-1. These ratios, along with the current dose-to-secondary piggyback set ratio of 1-to-1 are presented in Table 3. If

the ratio was held constant at the current 1-to-1 ratio of the piggy-back bottle system, the Harvard® system would cost $114,694 more to maintain in the implementation year. Therefore, as the dose-to-secondary microbore set ratio increases, the Harvard® system becomes more cost-effective.

Table 4 presents the final cost analysis of the two systems based on the minimum cost-effective dose-to-secondary microbore set ratio of 4-to-1. The number of secondary microbore sets purchased was greater than the number calculated for use by approximately 1,100 sets. These additional sets were purchases in accordance with a contract agreement for the purchase of full case lots of secondary microbore sets to pay for an initial 110 syringe infusion pumps that were anticipated to be utilized. An additional 10 syringe infusion pumps were projected for purchase over the initial 110 syringe infusion pumps. The Harvard® system would have proposed cost savings of $40,674 for the implementation year, and $71,454 for the second year. The projections for the second year were based on the same data used for the implementation year and did not assume any changes in usage or provider cost that could occur during these time periods.

DISCUSSION

The Harvard® Mini-Infuser System is a system for the intermittent intravenous administration of drugs that maintains acceptable standards for safety and drug delivery, and can provide a cost savings to the hospital and the Department of Pharmacy Services. Measurable areas of cost savings are personnel and material acquisition costs.

When comparing the personnel costs of the two systems, essentially no difference was found. However, variations were noted between the two systems. The Harvard® system required more time to transfer the drug to the syringe, and more time was needed to place the label on the syringe. These differences were probably related to an increase in manipulation of the syringe due to its size, as compared to a piggyback bottle. Also, stocking and retrieval of the syringe took more time to perform. This was probably related to the size and packaging of the syringe, which required the pharmacist to more accurately count and separate the number of syringes used.

Cost savings were demonstrated for material acquisition costs. These costs were itemized into fixed and variable costs. The difference in fixed costs was related to the use of the less expensive syringe. If the more expensive minibag is used in place of a piggyback bottle, this difference in fixed costs would be even larger. The difference in fixed costs was offset by the more expensive secondary microbore sets of the Harvard® system. At University Hospital, both systems employed the use of a primary intravenous solution with a primary infusion set and extension set. The primary intravenous solution and extension set were considered the same in both systems and were not included in the cost analysis. However, to reduce the higher variable costs of the Harvard® system, a less expensive primary infusion set was used in the Harvard® system. The higher expense was particularly evident if the dose-to-secondary microbore set ratio is maintained at 1-to-1, as it is for the current piggyback bottle system. Therefore, to realize a cost savings for the Harvard® system the number of doses administered per secondary microbore set

must increase to a ratio of at least 4-to-1 for the first year of use. Assuming four doses administered per 24 hour period, each secondary microbore set would need to be used for at least 24 hours. This length of use for a secondary intravenous set is within the guidelines established by the National Intravenous Therapy Association[6] for the intravenous administration of drugs. This change in usage pattern for the secondary microbore set, compared to the secondary piggyback set, would require both nursing personnel cooperation and education.

Cost savings were increased from the implementation year to the second year. This increase was related to the difference in cost of the secondary microbore sets of the Harvard® system. In the implementation year secondary microbore sets were purchased, under contract agreement, at the higher cost to allow the purchase of an initial 110 syringe infusion pumps. The following year, no syringe infusion pumps were projected to be purchased in this manner, and the cost of the secondary microbore sets was reduced. Future secondary microbore set purchase costs would then be based on the volume of sets purchased. An additional cost savings between the two years was based on the option to purchase an additional 10 syringe infusion pumps during the implementation year and not to purchase any syringe infusion pumps during year two. If more than 10 syringe infusion pumps were purchased during the implementation year the cost savings between the two years would be larger, but the total cost savings for the two years would be less. Cost savings in the second year would be less if any additional syringe infusion pumps were purchased during that year, and the total cost savings would be decreased, accordingly. The savings projected for the Harvard® system could be minimized by price increases for the

piggyback bottles and intravenous solutions if the provider determined that the usage of these products was now below prior contract agreement and increased the prices.

Inventory costs were not calculated for either system. However, changes in inventory were projected to result from the use of the Harvard® system. The frequency of ordering materials would not be expected to change, however, the number and type of items purchased would change. Storage space in the pharmacy stockroom would be gained, as less area would be needed to store an equal number of syringes, as compared to piggyback bottles. Additional pharmacy storage space gains would be possible at University Hospital as the pharmacy could order syringes from central supply as needed, thus decreasing the need to keep a large supply of syringes in the pharmacy stockroom. The secondary microbore set inventory purchased in excess of projections would require extra space for storage. However, this inventory would be distributed among pharmacy and the various patient care units at University Hospital and space requirements would be minimal.

Personnel attitudes are important factors in the complete evaluation of the Harvard® system, but were not formally investigated in this study. Subjective assessment of pharmacy and nursing personnel attitudes were very encouraging, since both found the Harvard® system to require minimal attention and effort to use. Problems, such as the initial determination of appropriate syringe size and type, and the need to determine whether or not the syringe was to be placed in the patient's unit dose medication cassette, did not deter this enthusiasm for the Harvard® system.

CONCLUSION

The Harvard® Mini-Infuser System is a system for the intermittent intravenous administration of drugs that meets acceptable standards for safety and drug delivery. The advantage of this system was a reduction in cost to the Department of Pharmacy Services at University Hospital. This cost reduction was related to the reduction in material acquisition costs, provided the appropriate number of doses of drug given per secondary microbore set could be determined and maintained. Personnel acceptance and a tentative reduction in nursing time concurrent with increased ease of use, although not measured in this study, would make the cost savings more acceptable to a hospital pharmacy administrator and hospital administration.

FIGURES

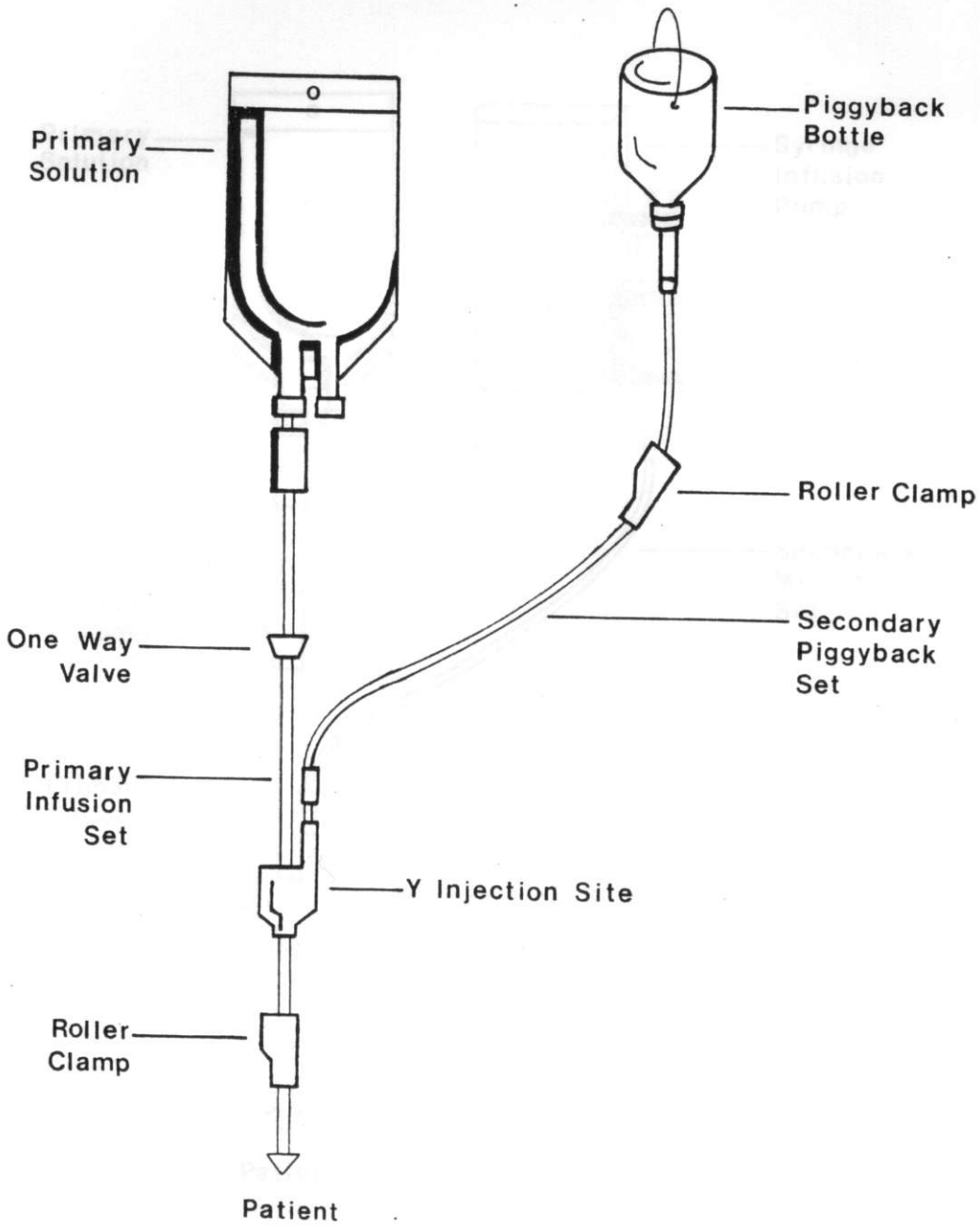

Figure 1. Piggyback bottle system.

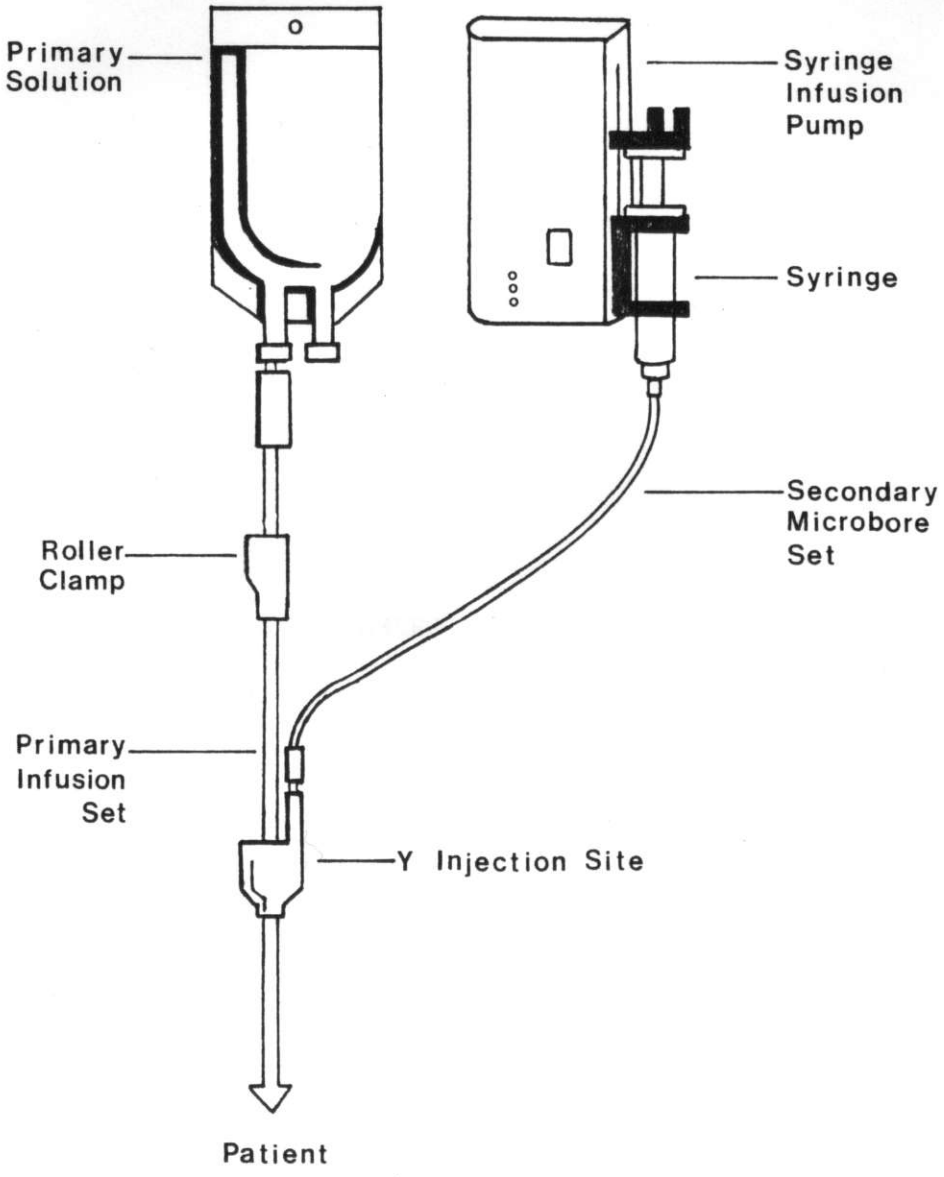

Figure 2. Harvard® Mini-Infuser System.

TABLES

Table 1. The mean (± standard deviation) time for activities that were performed differently for the piggyback bottle system and the Harvard® Mini-Infuser System.

	Seconds, per prepared dose	
Activity	Piggyback Bottle System	Harvard® Mini-Infuser System
Stocking/Retrieval	2.7 ± 2.0	3.4 ± 2.8
Transferring	10.9 ± 6.6	12.0 ± 4.0
Labeling	1.0 ± 1.4	1.9 ± 1.4

Table 2. Fixed and variable costs per dose for the piggyback bottle system and the Harvard® Mini-Infuser System.

	Piggyback Bottle System	Harvard® Mini-Infuser System
Fixed Costs		
Small volume container	$0.760	$0.140[1]
Label	0.020	0.006
Container safety seal	0.050	0.050
Transfer needle	0.020	-0-
Total	$0.850	$0.196
Variable Costs		
Secondary set	$0.820	$3.373[2]
Primary infusion set, with valve, adult	1.696	-0-
Primary infusion set, plain, adult	-0-	0.720
Total	$2.516	$4.093

[1]Average cost of various syringe sizes.

[2]This cost is $1.80 for second year of use.

Table 3. Cost effectiveness projections based on the ratio of the number of doses (D) given per secondary microbore set (MS), D:MS.

	Piggyback Bottle System	Harvard® Mini-Infuser System	Difference[1]
D:MS = 1:1 (MS = 67,592)[2]			
Primary infusion set, adult	$ 24,706	$ 10,488	$ 14,218
Fixed costs	57,453	13,248	44,205
Variable costs	45,431	227,988	(182,557)
Total	$127,590	$242,284	$(114,694)
D:MS = 4:1 (MS = 16,898)[2]			
Primary infusion set, adult	$ 24,706	$ 10,488	$ 14,218
Fixed costs	57,453	13,248	44,205
Variable costs	45,431	56,997	(11,566)
Total	$127,590	$ 80,733	$ 46,857
D:MS = 5:1 (MS = 13,518)[2]			
Primary infusion set, adult	$ 24,706	$ 10,488	$ 14,218
Fixed costs	57,453	13,248	44,205
Variable costs	45,431	45,596	(165)
Total	$127,590	$ 69,332	$ 58,258

[1]Piggyback bottle system minus Harvard® Mini-Infuser System.

[2]Denotes number of secondary microbore sets to calculate variable costs.

Table 4. Final cost analysis of the piggyback bottle system and the Harvard® Mini-Infuser System.

Piggyback Bottle System	Year One	Year Two	Total
Primary infusion sets, adult	$ 24,706	$ 24,706	$ 50,864
Secondary piggyback sets, adult	45,431	45,431	90,862
Fixed costs	57,453	57,453	114,906
Total	$127,590	$127,590	$255,180
Harvard® Mini-Infuser System			
Primary infusion sets, adult	$ 10,488	$ 10,488	$ 20,976
Secondary microbore sets	60,705	32,400	93,105
Fixed costs (syringes = 67,592)	13,248	13,248	26,496
Additional pumps purchased (#10)	2,475	-0-	2,475
Total	$ 86,916	$ 56,136	$143,052
Proposed savings	$ 40,674	$ 71,454	$112,128
Microbore set inventory above projection, dollars	$ 3,717	$ 1,984	$ 5,701
Microbore set inventory above projection, number	1,102	1,102	2,204
Microbore set inventory period above projection	3 weeks	3 weeks	6 weeks

APPENDIX

Activities identified during the preparation of intermittent intravenous drug doses.

1. Type labels
2. Batch separation of labels
3. Stocking/retrieval of materials[1]
   a. Syringes
   b. Piggyback bottles
   c. Diluent
   d. Drug already reconstituted
   e. Drug not reconstituted
4. Reconstitute drug
5. Transfer of reconstituted drug to small volume parenteral[1]
   a. Via multiple-dose syringe system
   b. Via transfer needle
   c. Via transfer pin and syringe/needle
   d. Via single syringe
6. Snap open ampules
7. Cleaning small volume parenteral with alcohol; remove seals
8. Sealing with volume parenteral
9. Label placement[1]
10. Initialing of label 11. Transfer small volume parenteral to cart
12. Adjustment of small volume parenteral for volume/pressure
13. Return materials to storage after use

---

[1]Activities that were performed differently for the two systems

REFERENCES

1. McAllister JC, Buchanan EC, Skolaut MW. A comparison of the safety and efficiency of three intermittent intravenous therapy systems - the minibottle, the minibag, and the inline burette. Am J Hosp Pharm. 1979; 31:961-67.

2. Miller WA, Smith GL, Latiolais CJ. A comparative evaluation of compounding costs and contamination rates of intravenous admixture systems. Drug Intell Clin Pharm. 1971; 5:51-60.

3. Paxinos J, Hammel RJ, Fritz WL. Contamination rates and costs associated with the use of four intermittent intravenous infusion systems. Am J Hosp Pharm. 1979; 36:1497-1503.

4. Stipe AA. Syringe infusion pumps: A delivery system for intermittent intravenous drug delivery. Infusion. 1980; 4:99-101.

5. Bard MedSystems Division, C.R. Bard, Inc., Harvard Mini-Infuser System product information. North Reading, MA. 1983.

6. Anon. Standards: Recommendations of Practice of the National Intravenous Therapy Association, Inc. NITA. 1982; 5(1):24-34.

CURRICULUM VITAE

Name	Robert Thomas Reilly
Birthdate	July 16, 1953
Birthplace	Tokyo, Japan
High School	Lewiston Senior High School Lewiston, Idaho
Universities	
1971-73	University of Idaho Moscow, Idaho
1973-76	Idaho State University Pocatello, Idaho
1982-84	University of Utah Salt Lake City, Utah
Degrees	
1976	Bachelor of Science in Pharmacy Idaho State University Pocatello, Idaho
1984	Doctor of Pharmacy University of Utah Salt Lake City, Utah
Honors	Rho Chi Pharmaceutical Honor Society, Idaho State University, 1975; Merck Sharp & Dohme Award, Idaho State University, 1976; Sandoz Pharm.D. Award, University of Utah, 1984; Ewart A. Swinyard Scholarship, University of Utah, 1983.
Professional Organizations	American Pharmaceutical Association American Society of Hospital Pharmacists Phi Delta Chi, Professional Pharmacy Fraternity Rho Chi Pharmaceutical Honor Society
Professional Positions	Pharmacy Manager, Low Cost Drug, Inc. Clarkston, Washington, 1976-81 Staff Pharmacist, St. Joseph's Hospital Lewiston, Idaho, 1981-82
Publication	Reilly RT. Evaluation of Carbenicillin. In Drugdex, Micromedex, Inc., Englewood, CO., March 1983