Methods for Reducing Outdating Without Altering Physician Ordering Patterns

by

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Introduction

The purpose of this work is to analyze and recommend certain policies and methods to reduce outdating in a department which significantly overorders without altering physician ordering practices. The policies and methods studied are whether to issue old or fresh units, and double and/or partial crossmatching.

The reduction of outdating of blood and blood components is a problem which requires continual reassessment by blood bank administrators. The reason for this reassessment is that with the growing therapeutic and prophylactic uses and the changing nature of supply from paid to volunteer donors, the increased demand for blood and components constantly puts pressure on the supply and inventory control of available units. Techniques and procedures which reduce outdating reduce this pressure.

However, in introducing management changes which reduce outdating it is essential to ascertain that the changes do not reduce the quality nor unnecessarily delay the delivery of the blood products. For example, one way to reduce outdating is to alter the physicians' ordering patterns by only allowing them to order prescribed quantities for particular medical and/or surgical procedures and needs. In departments where the physicians tend to grossly overorder (say, they only transfuse 10-15% of their crossmatch reserve), it is often the case that their crossmatched units are reduced in number. However, if these reduced quantities are below levels deemed reasonable by the physicians, or if the actual transfusion needs experience large variations even within the same procedure, not only are poor staff relationships fostered but, more importantly, many unnecessary delays are experienced both in the operating room and at bedside. The amount of these delays (in blood units) are examined in the "Results" section of this paper.

In reviewing the literature, it is apparent that there are many prior studies containing policies for the reduction of outdating. In recent years Rabinowitz [1970, 1973] analyzed double crossmatching policies, assignment of older blood to patients with high probability of transfusion, and use of older Rh negative blood for compatible Rh positive patients. He found that each of these policies leads to reduction in outdating; however, the double crossmatching obviously increased the number of crossmatches performed. Cohen and Pierskalla [1975], Pierskalla and Yen [1976], and Pinson [1973] analyzed ordering, issuing and crossmatch release policies for a regional blood bank and hospital blood banks. They found that use of the oldest blood first, minimization of the crossmatch release time and following optimal ordering policies reduced outdating and shortages. Other recent studies investigating ordering policy (theory and practice) are Jennings [1968, 1973], Nahmias and Pierskalla [197 , 197 , 197] and Bodily [1973]. Some older studies are listed in the references.

In addition to the policies suggested in the above studies, the AABB Procedure Manual [1975] contains the following:

"Hospital Inventories

.... Additional aids to controlling the blood inventory include:

1. "FIFO"--"first in, first out," i.e., using the oldest blood first unless contraindicated medically.

2. Multiple crossmatching of units for two or more patients simultaneously. The cooperation of the hospital's technologist or nurse is invaluable in implementing this practice. Physicians often develop routines. Dr. Doe, for example, always orders "x" number of units of blood for every patient with a case of "y" disease. The observant laboratory technologist, knowing that Dr. Doe generally uses only half of the blood ordered, or none at all, will crossmatch the same units for possible use by other patients.

3. Limiting the length of time crossmatched blood is held in reserve for any patient. Demand usually exceeds both supply and use. A policy of automatic release of unused blood 24 hours after it is ordered should be established.

4. Educating medical and surgical staff members in blood component use. Packed cells, platelets, cryoprecipitate, and single donor plasma (cryo-poor) can be salvaged from a single whole blood donation. The use of specific components meet specific needs thus may benefit many patients. Although some of these components, such as platelets, are relatively labile, others, such as single donor plasma, can be stored for long periods at--18^{o} C and are helpful to meet emergencies and disasters."

In undertaking this study, it was felt that perhaps the above mentioned policies in the articles and the AABB Procedure Manual might not apply to a relatively small department whose physicians tend to grossly overorder units relative to their actual transfusion needs. Furthermore, it was felt that a large amount of overordering was somewhat justified since (a) each order itself tended to involve only a few (two or less) units on the average, and (b) the variance in the actual transfusion needs was very great because much of the surgery was of an exploratory nature. Finally, it was felt that the blood bank provided an important service to the physicians and every reasonable effort should be made to meet their requests rather than hamper their activities or incur excessive patient stress and delays.

The next section contains background rationale for the policies tested, namely, LIFO vs. FIFO issuing, single vs. double crossmatching and partial crossmatching. The subsequent section contains the results of the analysis using data obtained from the Rush Presbyterian-St. Luke Medical Center. The final section contains a summary of the findings and a list of recommendations. For completeness we have included a detailed description of the simulation in the Appendix.

Background for the Analysis

In the control of outdating, the question "Should the blood bank administrator use the freshest (LIFO = last in first out) or oldest (FIFO = first in first out) blood when a crossmatch demand occurs?" was thought to have an obvious answer. Namely, always use the oldest blood first. This is the answer given by the AABB Guide [197] and also confirmed by the Cohen and Pierskalla study [1975] for a regional (or central) blood bank. Indeed, for a blood bank system which transfuses approximately 50% of the units crossmatched, they showed that under a reasonable crossmatch return policy (of the unused units), LIFO was an extremely poor policy. However, for an individual hospital blood bank our current study shows that a combination of LIFO and FIFO may lead to a significant reduction in outdating. In order to understand how this latter phenomenon occurs, it is necessary to look at the probabilities of a transfusion occurring given the unit was crossmatched. For example, suppose there is a department (call it A) in the hospital which only transfuses 10% of its total demand whereas the other departments (call them B) transfuse 50% of their demands. Furthermore, suppose that a unit of blood would receive, on the average, five crossmatches before it outdates (if it is not transfused).

Now if department A is allocated one unit of fresh blood and this unit stays with A until it is transfused or outdated, the probability that this unit will be transfused is about .41 (see Table 1), i.e., this unit would only have about a 40% chance of being transfused if it were exclusively assigned to A. Thus, its outdating probability is .59. On the other hand, if a unit were exclusively assigned to B, its probability of transfusion is .96875 (and its outdating probability is slightly more than 3%).

Of course, in general, it does not make much sense to assign a unit exclusively to A or B over its lifetime. In this hypothetical hospital if, say, only 20% of the total demand comes from A and the remainder from B, and if departments are randomly chosen, then on the average a unit of blood would receive one of its crossmatches for A and the remaining four for B. This unit's probability of transfusion now becomes .94375 (thus, the probability of outdating is just under 6%). This probability of transfusion (.94375) is only .025 lower than if the unit had not been crossmatched to A at all.

However, the .94375 probability applies only to a fresh unit entering the system. If the unit has only four crossmatches remaining in its useful life (i.e., it has already aged somewhat) and if it is crossmatched once to A and, if not used, then to B for its remaining crossmatches, the probability of transfusion is .8875. Furthermore, if there are only three, two or one remaining crossmatches and if it is crossmatched once to A and then subsequently to B, the probabilities of transfusion become .775, .55 and .1, respectively. Now it can be seen in Table 1 that the probability of a unit being transfused decreases dramatically as the number of times the unit is crossmatched to A increases or as the number of possible crossmatches decreases. So initially in the life of a fresh unit it is not too significant if the first crossmatch is made to A; however, as the unit ages, the impact of any crossmatches to A becomes very significant. The conclusion to be reached from this brief analysis is that only fresh units (say less than four to five days old) should be crossmatched to A and then only once to A in each of the unit's lifetimes.

Unfortunately, many blood banks are not able to turn over (i.e., crossmatch) their units five times in a unit's lifetime before expiration. This

Remaining Crossmatches \ Number of times crossmatched to A	0	1	2	3	4	5
5	.96875	.94375	.89875	.81775	.67195	.40951
4	.9375	.8875	.7975	.6355	.3439	
3	.875	.775	.595	.271		
2	.75	.55	.19			
1	.5	.1				

Probability of Transfusion*

Table 1

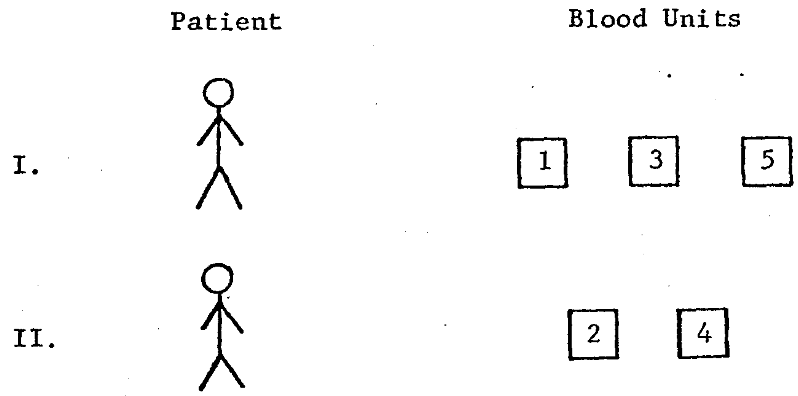
situation may be caused by several factors--the most common being (a) excessive stock on hand and (b) a long crossmatch release time (usually in excess of two days). In these cases, the probabilities of transfusion are drastically lower as can be seen from Table 1 for the probabilities when there are only four, three or two crossmatches for a unit. So, in order to raise the probability of transfusion for a unit (hence lower the probability of outdating), the blood bank administrator should also increase the turnover rate of the blood in his bank, i.e., increase the number of times a unit is crossmatched before transfusion or outdating. For purposes of this paper we will not address the turnover rate further, but rather we will discuss methods to reduce outdating for a given turnover rate. The subject of turnover rates and their control will be covered in a subsequent article.

*The probability of outdating is 1 minus the probability of transfusion.

In the above example, it was assumed that the blood turnover rate was five. Also, it was noted that the later in the life of a unit that department A received a crossmatch the greater the increase in probability that the unit will outdate. A hypothesis one would naturally propose is to crossmatch only new units to A and then do so only once for any given unit; the remaining crossmatches of that unit would be to department B. To test this hypothesis and others, a detailed simulation model of this situation was constructed (see the Appendix for a description of the simulation model). The results of the model and its policy implications will be discussed in the next section. But before describing these results, we mention a few other issues raised and also tested with the simulation model.

In an earlier study, Rabinowitz considered double crossmatching units to two patients of the same blood group. The idea behind double crossmatching is that the probability of transfusing some of the units will be raised (presumably the oldest units) and others will automatically be lowered (presumably the youngest units). The following example will clarify this phenomenon. Consider two patients, I and II, from the same group (type and Rh). Assume the physicians have ordered three units for patient I and two units for patient II, and label the units 1 through 5 as shown in the diagram below, with oldest units for each patient appearing on the left of the unit lists. For example, unit 1 is oldest and unit 5 is freshest of those allocated to patient I.

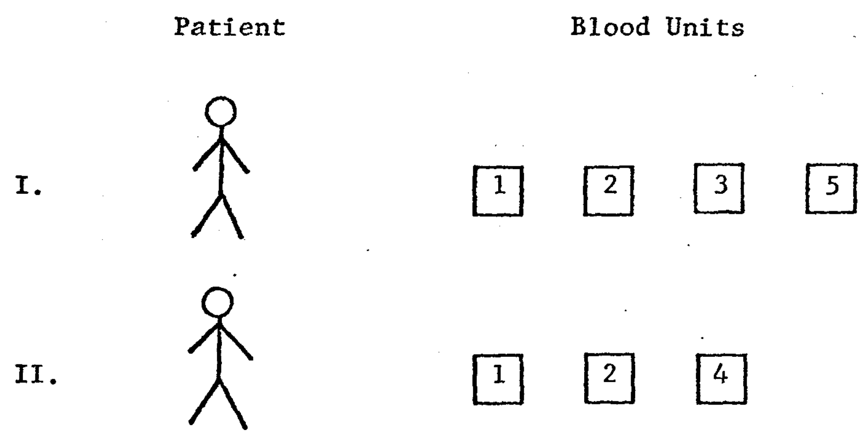
For single crossmatching, five crossmatches will be performed. For double crossmatching either seven or nine crossmatches will be performed depending upon the extent of double crossmatching desired. If units 1 and



Five Units Demanded - Three for Patient I
and Two for Patient II (Single Crossmatching)

Figure 1

2 are crossmatched to both patients, 3 and 5 only to patient I, and 4 only to patient II, then seven crossmatches are performed. In this case, each patient has the following units crossmatched:



Five Units Demanded - Three for Patient I and Two for Patient II
(Double Crossmatch Units 1 and 2)

Figure 2

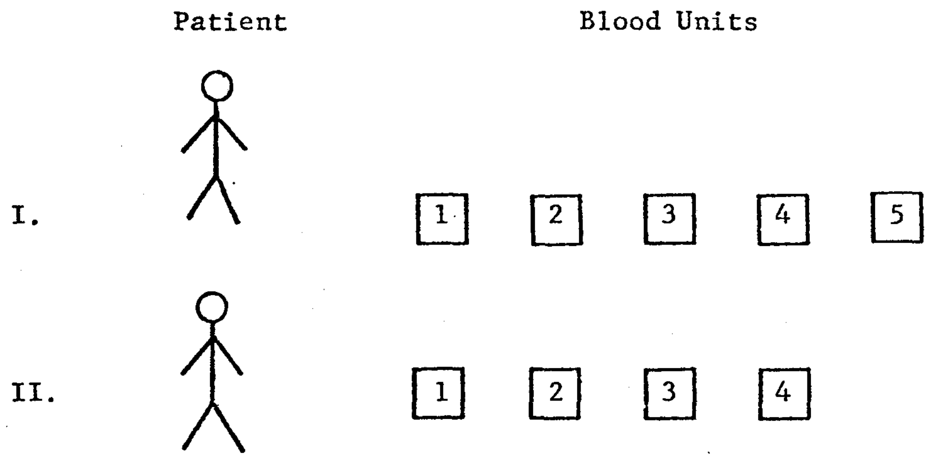
In the discussion immediately following, we assume the oldest units are issued first. Also assume that patient I receives transfusions before patient II. Then, if patient I uses only one unit, he receives unit 1. If patient I uses two or three units, he receives units 1 and 3 or 1, 3 and 5, respectively. Now, if patient II uses one unit, he receives unit 2. However, if patient I uses zero units and patient II uses two units, then he receives units 1 and 2. On the other hand, if patient II receives transfusions before patient I, the situation reverses in an appropriate manner such that patient I has at least three units waiting (i.e., crossmatched to him) when the need arises. Under this scheme, units 1 and 2 have a higher probability of being used than units 3, 4 and 5. Using the probabilities listed in Table 2, the probability of transfusing units 1 and 2 under single crossmatching is .3 whereas under this level of double crossmatching it is .38 if patient I is first or .45 if patient II is first.

i	0	1	2	3
Probability Patient I will use exactly i Units	.4	.3	.25	.05
Probability Patient II will use exactly i Units	.5	.3	.2	0.0

Probabilities of Usage for Blood Units
Assigned to Patients I and II

Table 2

These probabilities of transfusion can be raised even further if the first four units are double crossmatched (here nine crossmatches must be made). The resulting crossmatches and availabilities are:



Five Units Demanded - Three for Patient I and Two for Patient II
(Double Crossmatch Units 1, 2, 3 and 4)

Figure 3

Now, if patient I is scheduled first and uses two units, he receives units 1 and 2 and if he needs three units, he receives units 1, 2 and 5. Consequently, if patient II uses one or two units, he receives the lowest numbered units still available after patient I's transfusions. In this manner, the probability of transfusing unit 1 is .8 and both units 1 and 2 is .53. These probabilities are higher under this extensive double crossmatching; however, they are achieved at the expense of more crossmatches and the decrease in the probability of transfusing the fresher units. Table 3 summarizes the situations for this example. If patient II is scheduled first, the units used and the transfusion probabilities are slightly different.

Although Table 3 shows that the probabilities of transfusing the lowered numbered units rises as the amount of double crossmatching is increased, this improvement can only be achieved at the cost of the additional crossmatches and the loss of crossmatch links from the pigtail of the blood bag. Furthermore, the probabilities of transfusion for the higher numbered units are significantly reduced. It will be shown that the conclusions of this simple example also hold for the entire department under consideration. Indeed, in the next section it becomes apparent that the cost of double crossmatching in general exceeds its value in increasing the transfusion probabilities of the units.

	single crossmatch	double crossmatch units 1 & 2	double crossmatch units 1, 2, 3 and 4
Probability of unit 1 transfused	.6	.8	.8
Probability of unit 2 transfused	.5	.38	.53
Probability of units 1 and 2 transfused	.3	.38	.53
Probability of unit 3 transfused	.3	.3	.21
Probability of unit 4 transfused	.2	.12	.06
Probability of units 1-4 transfused	.06	.06	.06
Number of crossmatches	5	7	9

Probabilities of Certain Units being Transfused
Given Patient I is First

Table 3

Before proceeding to the next policy studied in this paper, it should be mentioned that if one knows for certain that the needs of patient I will occur before those of patient II, then the number of double crossmatches can be reduced for both the seven and nine crossmatch examples given above. In this event, crossmatching unit 2 and units 3 and 4 for patient I are unnecessary in the seven and nine crossmatch examples, respectively. The reason for eliminating these crossmatches is due to the fact that these units are not allowed to be transfused to patient I or else patient II's needs subsequently could exceed his available supply.

The third policy examined in this article is to crossmatch only a portion of the total demand received. With a department that has a transfusion percentage of only 10-20% of total crossmatches, it is reasonable to expect a reduction in outdating if only 1/2 or 2/3 or 3/4 of its total demands are crossmatched beforehand. Then if the actual transfusion needs exceed the number of units crossmatched, the additional units would be taken from an emergency supply of the same group or from the universal donor supply, type 0 negative. In the simulation several such partial crossmatch percentages were tested, under both single and double crossmatching.

Discussion of the Methodology

A computer simulation model was developed which captures the essence of the demand-crossmatch-transfusion process of a hospital blood bank, and was used to evaluate the various policies considered. Each simulation was run for a period of 500 days. The simulation model required an extensive set of daily patient data which was generated from empirical probability distributions and which consisted of the number of patients per day (of each blood group), the surgical procedure, the physician, the number of units demanded, and the number of units transfused for each patient.

This particular study was concerned with a single surgical department which transfused roughly 10-20% of the units demanded and whose total demand was only a small portion of the hospital demand. Data for such a department (which will be referred to as department A) was obtained from Rush Presbyterian-St. Luke Medical Center and used to compute the distribution of (1) the number of patients demanding blood on any given day (by blood group), (2) the surgical procedures unique to department A, (3) the physicians performing surgical procedures in A, (4) the number of units demanded given the surgical procedure, (5) the number of units transfused given the procedure and number ordered, (6) the number of units demanded given the physician, and, finally, (7) the number of units transfused given the physician and the number ordered.

Two different patient data sets were used, the difference being the empirical conditional distributions used to generate the number of units demanded per patient. In set I the conditioning was on the physician while in set II the conditioning was on the surgical procedure. The primary reason for using these two data sets was to establish the relationship between the policies used, the surgical procedures, the physicians and the outdates over a long period of time.

The method of the analysis was to implement various policies (to be discussed in detail later) in the model and run the simulation for 500 days. Two runs were made with each policy, corresponding to the two patient data sets (mentioned above). Portions* of the output of each simulation run were

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*See the appendix.

then used as input parameters in a simple but accurate outdate forecasting model which predicted the expected number of outdates. In this manner, it was not difficult to observe the relationship between the policy, surgical procedure, physician and the resulting outdates.

A thorough discussion of the simulation model and the outdate forecasting model is provided in the appendix.

The next section discusses the results of the analysis.

Results of the Study

Procedure versus Physician

The analysis established that there was no significant relationship between the physician and the number of units ordered within the surgical department analyzed. Furthermore, with the exception of radical procedures, there was not a significant relationship between the number of units ordered and the surgical procedure, within the particular surgical department analyzed. The most significant factor was the following interesting characteristic of the particular department studied: roughly 89% of the time, exactly two units were ordered independent of both the procedure and physician.

The numerical results presented in this section were obtained from simulation runs which used the patient data set based on the number of units demanded given the physician, unless otherwise specified. This particular choice was not made arbitrarily, as will be explained later. Many of the policies considered during the course of the investigation were based either on the physician or surgical procedure. Only those policies which are simple and unambiguous can be implemented in the blood bank, since it is desirable to minimize both the possibility of error by the technician as well as the extra effort on his part to use the new policy. The possibility of ambiguity is obviously very small when basing policies on the physician's name. However, this may not be the case when policies are based on surgical procedures because synonyms are often used to identify a particular procedure. Thus, the technician may have to consult an associate or another source to properly follow the policy.

Thus, the results presented in this section were based on simulation runs using patient data set I (generated using conditional distributions given the physician). This allows all of the policies to be easily implemented directly from the article. It was pointed out at the beginning of this section that the surgical procedure had little effect on the number of units demanded. Indeed, the results obtained using patient data set II were almost identical to those based on set I and so they are not presented in the article.

Fresh versus Old

In the introduction it was pointed out for a department which grossly overorders (say only 10-20% of its orders are transfused) how it might be the case that a LIFO policy will lead to lower outdating. The simulation was run first following a FIFO policy and then following a LIFO policy. Table 4 displays the results of these two 500-day simulation runs. There were 1753 units crossmatched and of these 164 units were transfused. Using FIFO the projected number of outdates was 643 units whereas under LIFO there were only 130 units outdated in this department.

These results in Table 4 assume that (a) FIFO is followed in the departments which do not grossly overorder, (b) the department has a small portion of the total hospital demand, and (c) if a unit is not transfused, it will have received at least four crossmatches prior to outdating. If a unit or units receive less than four crossmatches, then the projected number of outdates increase for both LIFO and FIFO, but LIFO is still the better policy to follow in this department which grossly overorders.

Policy	Projected Number of Outdates	Outdating as a Percent of Total Demands
FIFO	643	37%
LIFO	130	7%

Outdating Resulting from LIFO and FIFO Single Crossmatching in a Department which Grossly overorders (1753 units demanded and crossmatched; 164 units transfused)

Table 4

Single versus Double Crossmatching

The AABB Procedures advocate the multiple crossmatching of units to two or more patients simultaneously in an attempt to negate the effects of overordering. In the second section of the article it was pointed out that double crossmatching increases the transfusion probability of some of the units involved in the double crossmatching; this same phenomenon holds true in higher order multiple (i.e., more than two patients) crossmatching as well. Accompanying the increase in transfusion probability of some units is the decrease in transfusion probability of others. Thus, an important part of the analysis of multiple crossmatching involves the decision concerning the number and ages of units to choose with increased probability of transfusion and the number and ages of units with decreased probability of transfusion.

The probability of transfusion for a given unit is a function of the condition of the patient it is crossmatched to, as well as the surgical procedure and the physician. This argument indicates why patients involved in multiple crossmatching can have a significant impact on the success of the multiple crossmatching through the joint transfusion probabilities. Thus, important consideration muct be given to the patients who will be involved in multiple crossmatching.

When this study was undertaken, we considered multiple crossmatching as an approach to the reduction of outdating in the department which grossly overorders. It was soon apparent that only double crossmatching needed to be considered extensively since higher order multiple crossmatching did not yield further significant reductions in outdating over double crossmatching but did require a vast increase in the number of extra crossmatches performed.

Many different strategies were considered to determine which patients should be paired in a double crossmatching. The pairing strategies were based on (a) physicians, (b) procedures, and (c) conditional probabilities of transfusion. The probabilistic strategies consisted of computing the joint probabilities of transfusing portions or all of the units crossmatched (both singly and doubly) to both patients (see for example Table). A critical number (a cutoff number) was provided and the joint probability of transfusing a unit (between the two patients) was compared to the cutoff number. If this probability exceeded the cutoff number, the two patients would then be paired for double crossmatching; if not, both patients were processed as single crossmatch patients. Because of the nature of the transfusion probabilities of the department investigated (see opening discussion of this section), the probabilistic strategies were quite insensitive to the cutoff value, and thus little control could be exercised on the patient pairing problem. Hence, this class of strategies was not considered extensively.

The discussion opening this section points out that the demands and transfusions were dependent on the surgical department (as a whole) and not on individual physicians or procedures. Thus, not many interesting strategies could be developed to choose paired patients to improve the efficiency of double crossmatching. However, simple strategies were used to limit the number of pairings which could occur on any given day. For example, partition the medical staff of department A into two groups (say, I and II). Allow only patients with physicians from group I to be paired in a double crossmatching, while those patients with physicians in group II must be processed individually. By varying the number of physicians in each group and by singling out high demand physicians (those who had many patients), the number of pairings could be precisely controlled.

The decisions concerning the number and ages of units to choose oldest first and youngest first as well as the number of units to double crossmatch were based on the (a) physician, (b) procedure, and (c) conditional transfusion probabilities. The nature of department A caused many of the strategies to be insensitive for reasons alluded to in the opening discussion of this section. For this reason, it was very difficult to control the number of units and their ages to double crossmatch. There were only three reasonable choices: (a) all units would be double crossmatched, (b) one-half would be double crossmatched, and, finally, (c) none would be double crossmatched. Usually there were only four total units involved between the two patients, an additional reason why precise control was difficult. The most reasonable issuing policy used was to choose units oldest first for the double crossmatched units and choose units youngest first for the remaining units (which would be single crossmatched). Of the many policies used to determine the number of units to double crossmatch, the most reasonable was to double crossmatch one-half of the units demanded and single crossmatch the others. This policy closely resembles the policy used by Rabinowitz [ ].

Given in Table 5 are the results from following a policy of double crossmatching half of the units demanded (i.e., if the physicians demanded two units for each of two patients, then of the four units crossmatched, two would be double crossmatched and two would be single crossmatched for a total of six crossmatch procedures). Furthermore, the double crossmatched units would be chosen FIFO (oldest available), while the single crossmatched units would be chosen LIFO (youngest available).

By looking at Table 5, it can easily be seen that double crossmatching is better than single crossmatching with FIFO (i.e., 358 to 643 projected outdates). However, single crossmatching with LIFO for this department is far superior to double crossmatching (130 to 358 projected outdates).

Policy	Total Number of Crossmatch Procedures	Projected Number of Outdates	Outdates as a Percent of Total Demands
Double	2903	358	20%
Single with FIFO*	1753	643	37%
Single with LIFO*	1753	130	7%

Outdating Resulting from Single and Double Crossmatching in a Department which Grossly Overorders (1753 units demanded and 164 units transfused)

Table 5

Partial Crossmatch

Because of the great overordering in the department under study, it was thought that if only a portion of the total units demanded were crossmatched, then the outdating might be significantly lowered. Then, in the infrequent case in this department where the physician needed to transfuse all of the units he had originally demanded, an emergency crossmatch of the required blood group (type and Rh) or of universal donor (0^-) would be performed. This partial crossmatch policy would only be acceptable if the number of these emergency crossmatches was quite small.

Simulation runs of 500 days were performed. The partial crossmatch policies considered were those where 50%, 68% and 82% of the total units demanded would be crossmatched the day prior to transfusion. In addition,

*From Table 4.

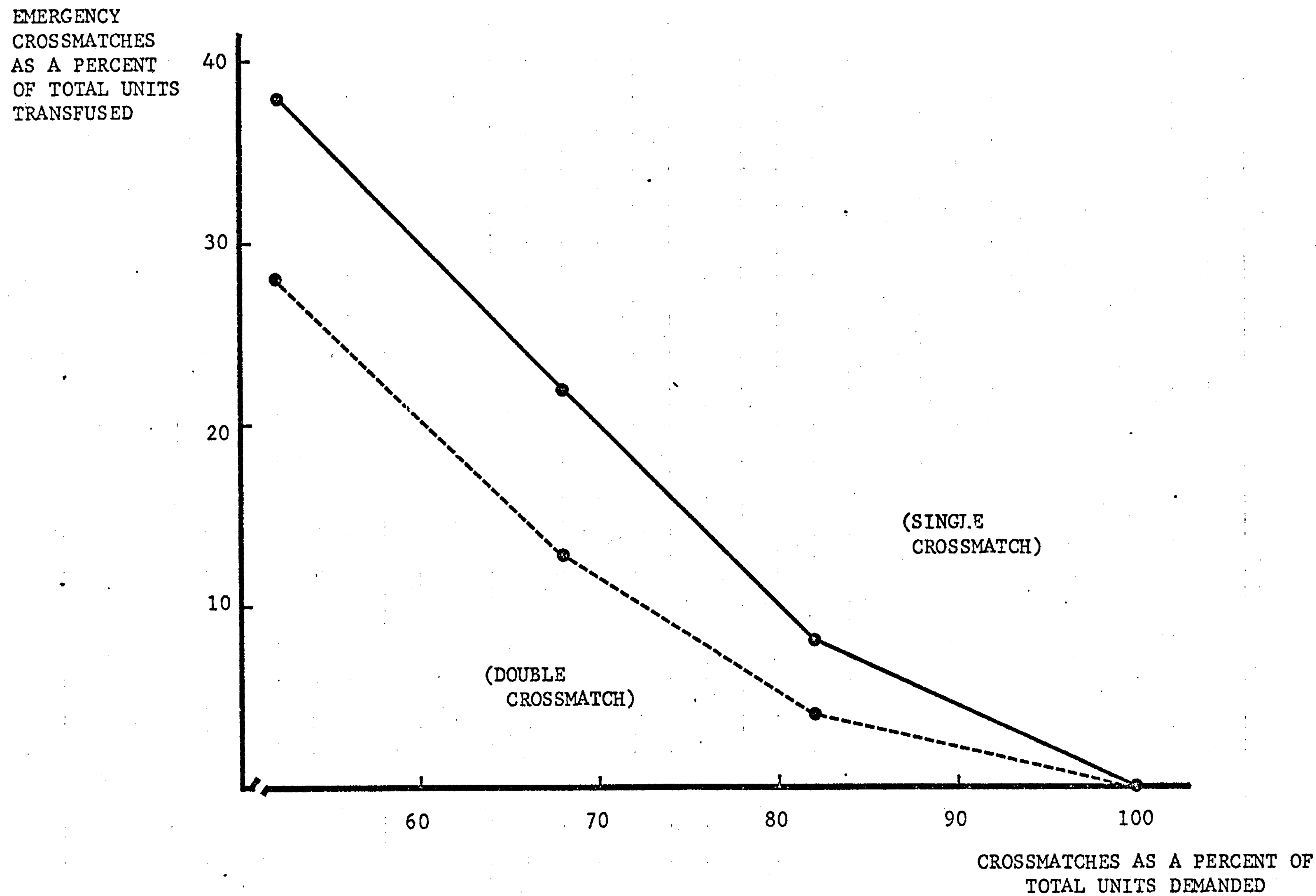
for those units crossmatched, runs were made both for single with LIFO and double crossmatching. The simulation results are given in Table 6, while the relationship between the degree of partial crossmatching (in terms of percentage of the demand size) and the degree of emergency crossmatches (in terms of percentage of the number demanded) is depicted in Figure 4.

From Figure 4, it should be noted that the emergency crossmatches as a percent of total transfusions is unacceptable except when almost all units are fully crossmatched. Even when one partially crossmatches 82% of the total demand, 5% or more of total transfusions must be met by emergency crossmatches and subsequent transfusion. In most hospitals the medical staff would not wish to delay transfusions 5% or more of the time; hence, such percentages would be unacceptable to them. Furthermore, crossmatching 82% of the demand versus 100% of the demand in this department which grossly overorders saves only 309 crossmatches in 500 days or less than one crossmatch per day. In addition, the number of outdates is only reduced by units. Therefore, as a policy, partial crossmatching results in too many emergency crossmatches and delays for the small saving in both the fewer number of routine crossmatches performed and the number of outdates reduced. It is conceivable, however, that partial crossmatching might be an acceptable policy under conditions of severe blood shortages, although this situation has not been studied here.

Before leaving this topic, it should be reiterated that partial crossmatching is equivalent to altering the physicians' ordering practices through requests to them to reduce the amount of blood ordered. From Table 6 and Figure 4, it is now apparent what effects such reduced ordering on their part would have. That is, as the percentage of their orders are reduced, they will experience a more than proportional increase in the percentage of transfusions which must wait for emergency crossmatching.

Percent of Total Demand Which is Crossmatched	Crossmatch Policy Followed and Number of Crossmatches	Projected Number of Outdates	Outdates as a Percent of Total Demands	Number of Emergency Crossmatches	Emergency Crossmatches as a Percent of Total Transfusions
50	Single 910			62	38%
	Double 1514			45	27%
68	Single 1196			36	22%
	Double 1896			22	13%
82	Single 1444			14	9%
	Double 2336			8	5%
100	Single 1753			0	0%
	Double 2903			0	0%

Table 6



TRADEOFF BETWEEN PARTIAL CROSSMATCHES AND EMERGENCY CROSSMATCHES TRANSFUSED

Figure 4