# Inventory management: connecting one arm to another

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**Abstract:** Blood collection and transfusion should be matched to prevent wastage and shortage. Communication and data gathering between hospital and blood center are essential tools. Each needs to gather data to work with the other to link collection to transfusion. Appropriate transfusion triggers, inventory management and blood ordering will minimize wastage. Modeling supply and demand in conjunction with each other can minimize shortages. Platelet planning is critical given the short shelf life of platelets. Data sharing and benchmarking between and among hospitals and blood centers can lead to better overall inventory management.

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The term "blood bank" is anachronistic. Blood centers are not banks in the financial sense. Deposits are not made and then extracted at some time in the future when needed. It cannot be stockpiled. Instead, it is a pipeline where we need to match the donors to the patients. This requires data on both sides of the equation. Too much blood and the resource are wasted, too little and patients suffer in need. Data needs to be in the context of units, a standard measure of patient need. It should not be measured in tons or gallons.

Donors should be extremely valued. They donate for various reasons, altruism to help others and help themselves feel good by doing well or to feel as a member of a group, i.e., social, work or community where donation is a group activity. Donors cannot be forced to donate but a bad experience may keep them away. If the donor discovers their donation has been discarded, they may be less willing to donate again.

From this perspective, it is important to begin with understanding demand. Demand is not distribution. Demand is actually what the hospital has requested not what the blood center has sent to them or can send to them. It doesn't matter when the blood center collects blood, but it must be matched to when the hospital needs blood. This is less urgent in red blood cells with a 35- to 42-day expiration but is extremely important for platelets which have a 5- or 7-day expiration of which the first 48 hours are spent in quarantine awaiting infectious disease or bacterial testing. For this reason, data analysis is most important.

In the past decade, blood centers have been integrating business principles into their processes. One of these is the formal sales and operations planning process. This is a decision making and communications process to integrate the business operational components with customer focused business plans. For us, each arm represents a customer. Key outcomes include high customer satisfaction, balanced inventory, stable production, higher productivity, better forecasting and fewer shortages. A strategic plan is established and operational plans are designed to meet it. Plans are monitored through active data collection and analysis. Deviations can be anticipated and handled with less confusion. Data is the key and it must be accurate. Accuracy can be a problem when there are multiple computer systems which do not balance with each other. Metrics may need to change over time as conditions change (1).

The crux of this paper is that data is the key to making good decisions. In this era of electronic health records, big data is available. In transfusion medicine, it can be used to benchmark against others, detect unusual transfusion related complications, determine blood use by procedure, help to define blood ordering schedules, develop key performance indicators to drive best practices in patient blood management and inventory management (2).

## RBC planning blood centers

Blood centers need to know their customers. It's important to look at the RBC demand this in total and also then by each individual hospital. Looking overall, the blood center must measure distribution against what is actually ordered or requested by the hospitals. It's important to know this by ABO/Rh and by week. Holiday anomalies should also be measured. By understanding demand and looking forward, blood drives and fixed site collections can be planned and scheduled to meet overall demand. Gaps between demand and collections can be proactively identified and filled through the use of special campaigns for recruitment. Modeling is important to align collections to gaps in demand. Overcollecting at the wrong times can lead to excess wastage. Unsatisfied demand must be balanced against excess wastage (3).

In the US and other developed countries while demand has declined, it has led to anomalies in the ABO percentages versus the standard donor population percentage, i.e., increased use of O negative. Likewise the number of antigen negative units has increased (4). To meet these needs and adjust the ABO/Rh mix between patient demand and donor population, telemarketing and recruitment can adjust recruitment up and down to get the right percentages. Just adding more drives increases wastage of those ABO/Rh groups which are in excess. Additionally utilizing double red cell machines or collecting concurrent products from apheresis donors can help adjust blood group percentages. If the hospital inventory is kept at a steady par level and the inventory level within the blood center rises, the age of the blood will increase within the blood center. This means reduced shelf life in units distributed to hospitals which leads to excess expiration on the hospital level (5).

Look at each hospital independently. Categorize them by type—primary or specialized, size, and services provided. Compare them so that you may find outliers with regard to ABO/Rh percentages. Another area to look at is how the hospitals are ordering product. How much of the product is by standing order, i.e., Routine deliveries by day of the week *vs.* stat or emergency orders. To minimize costs, 80–90% of the blood used by a hospital should be on routine delivery. Excessive stat or emergency orders indicate there is not enough blood at the hospital and patients need to wait for transfusions. Demand may need to be examined by hour of the day. Some of the largest hospitals have bimodal peaks in demand and consequently need two deliveries per day. Unlike a financial bank, blood should be in the hospitals for patient use rather than having excess amounts stored at the blood center. Another area to examine is cancelled hospital orders. These can be examined by day of the week and also by ABO type to understand usage patterns. Other areas to monitor include use of specialty products—CMV negative, sickle tested, irradiated, washed, antigen negative, etc.

One way to gather data and improve customer service is through the use of electronic ordering. Blood centers have implemented electronic order systems through which the hospitals order blood. This minimizes the use of telephone order takers and can track hospital ordering versus blood center shipments without having to track data manually. In some settings, there is complete transparency with the hospital able to look at blood center inventory and the blood center able to look at hospital inventory. In the UK, there is use of a web based management system and the blood center and all hospitals can look at each other's inventory and benchmark against each other (6,7). In certain blood centers, the blood center manages the hospital inventory and keeps it at certain par levels under contract with the hospital (8). Understanding how a hospital manages their inventory is important to know. How many days of inventory are kept in the hospital? Is the ABO percentage appropriate? Who is doing the ordering? An interesting finding was that letting the hospital computer determine the order from the blood center was better than having a person visually inspecting the inventory and doing the ordering (9).

## RBC planning hospital

In addition to blood centers gathering data, the hospital should be gathering and analyzing their own data. Which departments are ordering the most blood? It has been found that 3% of surgical patients used 55% of transfusion resources utilized in surgical patients and 3% of medical patients used 80% of transfusion resources utilized in medical patients (10). From a timing perspective for deliveries, when are the clinicians ordering—by day and time? Is there over transfusion? Are clinicians following a restrictive strategy recommended by AABB and European regulatory agencies? How is the blood bank monitoring ordering and adherence to the guidelines? Blood use in the US has declined 15–20% in the past ten years with adherence to a restrictive policy (11). The AABB recommendation is transfusion at less than 7 gm/dL except for those with pre-existing cardiac cardiovascular disease which can be transfused at less than 8 gm/dL (12).

The hospital needs to have an internal mechanism to set transfusion policy. Usually this is done by the transfusion committee, a group of clinicians representative of those who use blood, anesthesiologists, surgeons, oncology, and blood bank. Next is education of the clinicians as to the policy and appropriate transfusion (13). This is followed by active prospective review of orders and comparing them to recent hemoglobin values. Previously this was time consuming when done manually. Now, most hospitals have electronic medical records which utilize electronic ordering. Tied into the electronic ordering is clinical decision support with guidelines for transfusion. If the ordering physician is not within guidelines, an explanation must be given for why this patient requires transfusion. This can be reviewed by the blood bank medical director prior to transfusion. The electronic system also allows each department to track their clinicians and benchmark performance by procedure. This can take up to two years for adherence but can result in cutting usage by 25% (14-17).

Another area for hospitals to concentrate on is wastage. The wastage rate for red blood cells is roughly 2.4% (18). Wastage can come in various ways. First is expiration due to too much blood on the shelf. Staff should be educated as to financial, moral, and ethical implications of wasted units and overordering. An international review of inventory management shows most inventories are in the 5- to 10-day range so orders should be modified for that level (19). Modeling has shown that maintaining a 5-day inventory compared to a 10-day inventory reduces the age of the blood released to patients by approximately 6 days (20). Stock should be rotated so first in first out (FIFO) inventory management is used. Hospital should also be tracking the age of blood received from the supplier. Certain ABO groups tend to be distributed at an older age. All inventories should be visible to blood bank. This includes what may be stored in emergency room, operating room, or outpatient area refrigerators. Depending on the hospital, up to 20% of the units can be in places other than the blood bank. The more trips the units make outside the blood bank, the older they tend to be at transfusion and the more likely they are to expire (21). For multi-site transfusion services, use of a dashboard showing location, ABO/Rh, and dating can assist in maintaining FIFO through effective stock rotation and minimizing expired products (22). Hospitals and blood centers should considering splitting large once a week orders to multiple day orders so as to get mixed expiration dating on the units.

To minimize the size of the inventory and lower outdates and shortages, electronic crossmatch should be used with a reduced hold time on cross-matched units of 24 hours post procedure. When you do the crossmatch is important. Doing it far in advance will require more inventory and higher potential for wastage (9). Lowering the variation in the daily demand will lower outdates and shortages. Hospitals with low variation can use older inventory whereas those with much volatility need younger blood from the supplier (23). Older units should be cross-matched for in-patients most likely to be transfused (24).

Is your maximum surgical blood ordering schedule (MSBOS) up to date? It is important to remember why there is a MSBOS. It's there to remind surgeons that some types of patients and procedures are most likely to need blood and therefore need type and crossmatch prior to surgery. It's not there as a required order. Most schedules were set up by consensus years or decades ago with no revision. Now, actual data should be used to establish it. Many procedures do not require blood yet there are still type and cross or type and screen orders being done especially in elective general surgery (25). Most surgical procedures are using much less blood than in the past. This will lower your crossmatch to transfusion ratio resulting in fewer units needed in inventory and less labor (26). Modifying the MSBOS based on a year's worth of data resulted in an 18% decrease in units crossmatched with 11% fewer units transfused. There was also a reduction in type and screen by 6–7% (27). One study in a major urban medical center showed that 72% of blood was returned from OR back to blood bank and 71% of patients for whom blood was sent to the OR were not transfused. All of this results in a lot of wasted work and requirements for an inventory are larger than necessary (28).

Another cause of wastage is temperature. While this is not a problem in blood banks with temperature monitoring and back-up refrigerators, this occurs when blood leaves the blood bank. Are the transport containers validated for the amount of time blood is out of the refrigerator? Is clinical staff trained to appropriate handling of blood products? Are units forgotten or lost in the emergency room or operating rooms? Units need to be returned to the blood bank in the appropriate transport containers.

## Platelet planning blood center

Platelets are more complex from a planning perspective.

Platelet expiration rates can vary between 12% and 17% (18). In addition most hospitals use an order up approach where they simply order to fill a specific par level. More data is needed on both sides. In addition to tracking by ABO/Rh it's important to track demand by day of the week due to the short expiration dating. Usage will be different by hospital dependent on the services provided, types and schedules of surgeries, oncology protocols and outpatient schedules. Demand and orders should also be examined by hour of the day. Some of the largest hospitals have bimodal peaks in demand and consequently need two deliveries per day particularly for platelets which may have multiple release times throughout the day at the blood center.

In most blood centers, 20% or less of the hospital customers may account for 80% of the platelets ordered and transfused. One should estimate to cover at least 95% of demand with less than a 5% outdate. Mathematically this can be modeled to be a half to one standard deviation over the mean. The Dutch (Sanquin) use stochastic dynamic programming combined with simulation to account for demand uncertainties. The use of this modeling also enabled the average age of the platelet distributed to drop by half a day (29,30). Simulation modeling has shown that more collections are not necessarily better as wastage rates tend to go up. Fewer collections though may result in backorders. Through the use of modeling, wastage rates can be cut in half (31). Care should be taken to observe patterns of use, before during and after holiday periods as usage changes and donors may not be available. Blood centers may want to have limited collection hours during holidays to collect only platelets. To avoid wastage blood centers should know which hospitals will accept platelets with less than 24 hours to expiration. Likewise smaller hospitals with same day expiration should be encouraged to return platelets in a timely manner so they can be used by others.

From a collection perspective, data needs to be gathered on split percentage by site along with vacancy rates for seating per site, per day. Collections should be optimized to gather more split and concurrent products per donation keeping single product donations to a minimum. Sites should be open at those days and times when appointments are most likely to be fulfilled. Demand information should flow from distribution to collections to show which products need to be collected and are in short supply.

## Platelet planning hospital

Hospitals have an obligation to do their part to gather data and analyze it. This is much like red blood cells analyzing which departments are ordering and when by day and time? Again are they following AABB or international guidelines for transfusion or is there over transfusion (32)? Usage can also vary by clinician requirements for adherence to ABO identical or compatible products dependent on the service. This can be extremely challenging for the hospital and the blood center. In a review done by a university hospital of some 10,000 apheresis transfusions, 54.6% were ABO identical, 32.4% were ABO plasma compatible but cellular incompatible, 12.23% were ABO plasma incompatible, cellular compatible and 0.74% were plasma and cellular incompatible. For Rh, at least 83% of Rh negative patients received at least one Rh + platelet (33).

The same processes are needed to monitor or rationalize appropriate use of platelets as for red blood cells. Wastage in particular should be monitored due to short shelf life and environmental storage conditions. It is estimated that wastage rates for apheresis platelets is 12.8% (18). A review of international practice indicates that hospitals will keep 1–3 days of inventory (19).

A study where the hospital collects its own platelets and is self-sufficient revealed some very important trends which can help to isolate and solve problems. Outdated units for the most part are related to a mismatch between supply and demand. This can be seen by comparing outdate rates by day of the week which relates to day of the week collections. Outdates are higher with older units arriving at the transfusion service. Platelet transfusions vary by day of the week, therefore orders and inventory levels need to be different by day of the week. Changes implemented to lessen expiration were: collections were altered to match demand by day of the week, when rotating platelets among different transfusion services more than one day of shelf life are needed by the receiving hospital, inventory levels in the hospital were defined as 90% of usage, platelets are arranged on the rotator by expiration date not ABO. As a result, wastage dropped by a third from 12% to 8% and median age of platelets dropped by half a day (34).

Specific to platelets, hospitals need to anticipate usage by patients. A significant portion of platelets are used by the same patients. It's important to track and anticipate this usage. In Canada, Nova Scotia, they have developed a dashboard for platelet usage. They track patients with a platelet count below 50,000 and also track available platelets by ABO and date so they can be matched. To do this efficiently required tying hospital and lab computer systems together (35). Johns Hopkins University employs a different approach utilizing platelet transfusion coordinators. They work with the physician to provide therapy. They track each patient in the computer recording needs, pre and post transfusion counts, ABO/Rh so that needs can be anticipated and appropriate numbers of platelets ordered in advance (36).

## Information sharing

Data gathering is good but it must be shared between both sides. Monthly or quarterly meetings between individual hospital and blood supplier are required. You must know your customer, blood centers their hospitals, and hospitals their patients. The data should be shown, analyzed and explained by both sides. Without this understanding, demand cannot be adequately met. It's important to show individual performance against benchmarks of similar hospitals. This should be a frank discussion to show strengths and weaknesses with opportunities for improvement on both sides with regards to supply, demand, logistics, ordering patterns, etc. Benchmarking can offer significant improvements in wastage cutting it by 50% (37).

Planning should occur with regard to shortages which are inevitable particularly around holidays. Most important will be how and when will blood centers notify hospitals. Early notification regarding red blood cell shortages can alert hospitals to initiate their shortage plans allowing the blood center to cut hospital orders early and lightly knowing how hospitals handle their inventory. The Canadians have set up a regional notification in Ontario with varying levels of severity (38). Hospitals notify their medical staff and lower transfusion triggers to Hgb levels of 6 or 5 gm/dL depending on severity. With regard to platelets, blood centers may initiate production of whole blood platelets pooled or single units. Hospitals may begin more intense scrutiny of platelet orders, lowering the transfusion trigger to 5,000, use of half dose apheresis, and/or use of Amicar for mucosal bleeding.

The process of planning and training for shortages can be educational. A retrospective review done in Canberra, Australia to prepare for shortages revealed that the most effective way to deal with shortages was to prevent inappropriate transfusions which amounted to 17% of all red blood cell transfusions. This required vetting each request for transfusion (39). A study done in a major UK teaching hospital indicated that 74% of transfused blood went to medical patients. In planning for shortages, 11% of blood could be saved if major elective surgeries were cancelled. However, for non-life threatening bleeding using a scenario of a post transfusion target Hgb of 8 for non-ischemic and 9 for ischemic heart disease patients, over 23% of blood could be saved. Lowering these targets by 1 gram each increased the savings to 47%. Again policing the medical usage is more important than cancelling surgery (40). The largest and most comprehensive hospitals may consider having a frozen inventory of red blood cells using a system which allows for 14-day dating after thawing (41).

Inventory management is a study in data gathering and analysis. It must be done both in the blood center and the hospital blood bank. Cooperation, transparency, and coordinated planning will lead to better alignment between the donor arm and the patient arm.

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