Improving the Blood Supply Chain with Advanced Shipping and Storage Materials

Innovative Ways to Reduce Waste, Inefficiencies, and Compliance Hassles
Transporting blood products from donor to patient for transfusion is often an inefficient and costly process. In fact, the modern blood supply chain includes 7 points of failure where any delays, miscommunications, or procedural issues can cause serious problems.

Most blood banks, diagnostic labs, and hospitals use blood transport and storage materials that may not have been designed or ideally suited for that purpose. This creates inefficiencies in handling, and requires time-consuming validation to remain compliant with regulations.

Blood products are costly, and any spoilage can cause shortages and put human lives at risk. And any avoidable losses affect the financial results for the blood banks and hospitals handling those products.

A more reliable, cost-effective solution for transporting blood products is needed. This paper explores this issue and concludes that advanced packaging for this purpose is now available.
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As shown in Figure 1, blood and blood products must go through a series of steps before they are transfused into the patient. This is known as the **blood supply chain**, which may be defined as a **temperature-controlled supply chain**.

At each step in the blood supply chain, precise temperatures must be maintained to ensure the integrity of the blood products. Too cold or too warm, and the blood products may become unusable.
Steps in the Blood Supply Chain
(1) The donor gives blood.

(2) After donation, blood units and donor blood specimens are placed into cold storage containers and transported to the blood bank which may be many miles away.

(3) At the bank, blood is tested, processed, and stored according to precise specifications determined by the blood bank in compliance with AABB standards.

(4) When ordered, blood products are again placed within cold storage containers and transported to the hospital or other location where blood is needed.

(5) When received by the hospital, the blood products are again stored according to precise specifications determined by the hospital in compliance with AABB standards.

(6) When ordered by the physician, blood products are packaged and delivered to the patient’s bedside.

(7) Finally, the blood is transfused into the patient as needed.

Each of these 7 steps represents a possible point of failure where any delays, miscommunications, or procedural issues can cause serious problems.

Returned Blood and Blood Components
Often, there will be a need to return blood, blood components, to the blood bank/transfusion service. This is possible only if:

(a) The container closure has not been disturbed,

(b) The appropriate temperature has been maintained,

(c) For red blood cell components, at least one sealed segment of integral donor tubing has remained attached to the container. Removed segments shall be reattached only after confirming that the tubing identification numbers on both the removed segment(s) and the container are identical, and

(d) The records indicate that the blood, blood component, tissue, or derivatives have been inspected and that they are acceptable for reissue.¹
Blood products represent an expensive and labor-intensive resource, accounting for approximately 1% of hospital expenditures.² Yet the transportation and storage of blood products is often an inefficient and costly process. This is due to the complexity of the supply chain: the series of refrigerated production, storage and distribution activities, equipment, and logistics required to maintain a desired low-temperature range.

As shown in Table 1, blood products must be maintained within a critical range of temperatures during a short timeframe to remain viable. The steps listed under “Condition” in Table 1 refer to the steps in the blood supply chain shown in Figure 1.

These include 5 out of 7 steps where any delays, miscommunications, or procedural issues can cause blood products to go out of safe temperature range. This is also true for blood and blood components being returned to the blood bank or transfusion service.

Red blood cell (RBC) product wastage in hospitals is reported to range anywhere from 0.1% to 6.7%. In one study, approximately 87% of wasted RBC units were either individual units that were out of blood bank for more than 30 minutes (dispensed but not administered) or units packed in transport containers with temperature indicators affixed to each unit.

Factors identified as contributors to RBC wastage most amenable to improvement were lack of awareness and training of staff ordering and handling RBC products, management of temperature-validated containers, inconsistent interpretation of RBC temperature indicators, and need for accountability when ordering blood products.³
Table 1: Blood Product Transport and Storage Requirements

<table>
<thead>
<tr>
<th>Blood Product</th>
<th>Condition</th>
<th>Temperature Range</th>
<th>Transport/Storage Time</th>
<th>Transport/Storage Equipment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Whole blood and packed red cell</td>
<td>For transport to another center (steps 2, 4)</td>
<td>+1 °C to +10 °C</td>
<td>Depends on qualified duration of the container</td>
<td>Qualified container having sufficient cooling materials</td>
</tr>
<tr>
<td>Whole blood and packed red cell</td>
<td>For storage in blood center (steps 3, 5)</td>
<td>+1 °C to +6 °C</td>
<td>35 days</td>
<td>Blood bank / Hospital refrigerator</td>
</tr>
<tr>
<td>Platelet concentrates</td>
<td>For transportation to another center (step 4)</td>
<td>+20 °C to +24 °C</td>
<td>24 hours (maximum time without agitation)</td>
<td>Qualified container having sufficient temperature stabilization materials</td>
</tr>
<tr>
<td>Platelet concentrates</td>
<td>For storage in blood center (steps 3, 5)</td>
<td>+20 °C to +24 °C</td>
<td>5 to 7 days</td>
<td>Platelet incubator with agitator</td>
</tr>
<tr>
<td>Fresh frozen plasma</td>
<td>For storage in blood center (steps 3, 5)</td>
<td>Frozen state (below -18 °C)</td>
<td>12 months from collection</td>
<td>Plasma freezer</td>
</tr>
<tr>
<td>Fresh frozen plasma</td>
<td>For transport to another center (step 4)</td>
<td>Frozen state</td>
<td>Transported until maintained in frozen state</td>
<td>Qualified container having sufficient cooling materials</td>
</tr>
<tr>
<td>Packed red cells, thawed plasma</td>
<td>Blood components issued for transfusion (step 6)</td>
<td>+1 °C to +6 °C</td>
<td>Depends on qualified storage duration of the cooler</td>
<td>Portable coolers</td>
</tr>
</tbody>
</table>

Sources: AABB, WHO
Cost of Blood Wastage is Significant

In one study, the annual direct cost of intraoperative RBC wastage at Vanderbilt University Medical Center (VUMC) amounted to approximately $249,314 in 2010, using an estimated direct cost of $225.42 per unit of leukoreduced RBCs. This figure does not account for the overhead costs associated with the procurement, management, storage, and issue of these products. (National Blood Collection & Utilization Survey, 2011)\(^4\)

In a French study (2013), blood wastage during transport related to these problems: inappropriate temperatures (28.4%), no temperature indicator (4.3%), container products not correctly handled (4.8%), and transport not available (0.2%) (Zoric et al)\(^5\)

“According to the Journal of Clinical Oncology, the cost to have a blood transfusion can range from $1800 to $3000 per unit of RBCs transfused. The acquisition cost of a unit of RBCs is approximately $200.”\(^6\) This cost does not include the indirect costs of labor reagents when preparing a unit of RBCs for transfusion, which are lost since the unit cannot be reissued to another patient.

Not only are blood products costly, but unnecessary losses or spoilage can result in shortages and put human lives at risk. A more reliable and cost-effective solution is needed.
As primary packaging, blood banks and hospitals predominantly use cardboard boxes lined with polystyrene insulation, or else molded plastic coolers from consumer vendors such as Igloo and Rubbermaid.

Most of these grocery market coolers are not designed for precision insulating, so they have non-uniform temperature distribution with hot and cold zones within them.

The predominant cooling material used during transport of refrigerated products (whole blood, packed red blood cells) is bagged crushed ice and gel packs which often require preconditioning, leading to delays and slower response time. Most of the platelet shippers currently in use rely on regular gel packs to maintain payload at controlled room temperature (+20 to +24 °C).

The many drawbacks to these existing materials fall into three main categories:

- **Poor quality or effectiveness**
- **Time-consuming compliance or validation**
- **Excessive costs, including for shipping**

**Quality—limited capacity:** Igloo, Rubbermaid or similar coolers used by hospitals for internal transport are made from high-density plastic lined with 1.5- to 3-inch foam insulation, and then filled with crushed ice. This leaves only 20% to 30% of usable volume in which blood products can be placed.

**Quality—poor thermal performance:** Traditional packaging uses Styrofoam (R3 to R4 per inch) or polysisocyanurate (R5 to R7) insulation. While these are inexpensive, they provide limited performance in demanding settings, such as longer transport times, or at the bedside of a patient who requires continuous lower-volume transfusions.

**Quality—lack of flexibility:** As shown in Table 1, different blood products require different temperature ranges for packaging. The insulation, cooling material, and pack-out must be varied based on the type of blood product being packaged and transported. In simple terms, one size does not fit all.

Yet the existing materials used by blood banks and hospitals have little flexibility to size up or down according to the requirements of each shipment. This adds inefficiencies and higher costs.

**Compliance—arbitrary collection:** Many blood banks and hospitals today use an arbitrary collection of packaging materials that requires an extensive set of pack-out evaluations. A pre-validated system of integrated packaging and components would be faster and simpler to evaluate.
Compliance—primitive materials: According to William Laboratories, “In our March 2012 survey of over 70 blood banks, many respondents generally described cooler validation as a ‘pain,’ characterizing it as time-consuming, frustrating and even primitive.”

Compliance—time-consuming tests: Technicians and blood bank supervisors must spend a considerable amount of time evaluating different pack-outs (coolers, ice packs, cardboard boxes, plastic shells, and trolleys) from different sources.

They must spend many hours (in some cases 50 to 100+ man-hours) running multiple tests to qualify a system and comply with FDA/AABB standards. And to remain compliant, they must conduct periodic test runs every 6 to 12 months.

Costs—shipping: Blood banks typically use cardboard boxes, lined with insulation panels and 10 to 20 lbs. of crushed ice per box. This increases the weight and the shipping cost.

Note that shipping companies charge based on dimensional weight, so that packaging design should be optimized for both the size and weight of the container. The combination of limited capacity, limited thermal performance and heavy crushed ice often requires boxes to be shipped overnight, which increases the costs.

Even though the current packaging system is inexpensive, the total cost (packaging + shipping + product wastage + compliance) is very high. An optimized pack-out design should reduce product wastage, while significantly reducing shipping costs.

Costs—advanced materials not designed for blood: A few vendors offer expensive vacuum insulation panel-based packaging (VIP), R-20 to R-40 per inch. But VIP is relatively fragile, heavy, and cost-prohibitive for high-volume applications such as blood banks or hospitals.

This high-end design is best-suited for transporting more costly or irreplaceable items such as pharmaceuticals, biosamples, and organs for transplant.

R-Values. An insulating material’s resistance to conductive heat flow is measured in terms of its thermal resistance or R-value. The higher the R-value, the more effective the insulation. The R-value depends on the type of insulation, its thickness, and its density.
Selecting Blood Transport and Bedside Storage Materials

For guidance in selecting more effective blood transport and bedside storage solutions, two checklists are provided below for blood banks and hospitals.

Checklist for Blood Banks

- **Capacity**: How many units of blood can be carried?

- **Weight**: What is the weight when fully assembled with cooling materials and blood products?

- **Cooling materials**: Are payload-specific cooling materials included in the packaging system?

- **Shipping duration**: How long will the packaging system keep the correct temperature?

- **Durability**: Can the cold box survive the normal shocks and impacts it will be exposed to?

- **Method of transport**: Is the packaging suitable for transport by blood bank fleet, volunteer drivers, door-to-door specialty couriers, or third-party logistics providers such as UPS or FedEx?

- **Price**: Which cold box meets all the requirements listed above for the lowest cost? Does this include the cost of original materials, shipping costs for fully loaded weights, and how many times the materials can be reused?

- **Purpose-designed**: Have all the materials and pack-outs been designed specifically for transporting blood products? Does the design include advanced insulation technology and innovative pack-out design to increase capacity, extend shipping duration, and lower total cost?

- **Integrated system from a single source**: Do all the materials belong to an integrated, turnkey system from one vendor?

- **Flexibility**: Does the system provide all the components necessary to successfully package every type of blood product?

- **Pre-validation**: Does the system carry its own pre-validation report to save buyer’s time and money on evaluation and compliance?
Checklist for Hospitals

☐ **Capacity:** How many units of blood can be carried? Does the cooler capacity meet the requirement for transfusion protocol?

☐ **Weight:** What is the weight when fully assembled with cooling materials and blood products?

☐ **Cooling materials:** Are payload-specific cooling materials included in the packaging system?

☐ **Storage duration:** How long will the packaging system keep the correct temperature? Has this been pre-validated by the supplier to save steps in validation?

☐ **Time to pack and issue coolers:** Are there any special pre-conditioning steps involved before issuing a cooler (e.g. thawing gel packs)?

☐ **Pack-out consistency:** How consistently can the cold box be packed by lab technicians? How consistently does it avoid seasonal product loses due to changes in ambient environment?

☐ **Pack-out validation:** How efficiently can the cold box be validated for consistent performance?

☐ **Pack-out simplicity:** Does the system simplify and eliminate steps within the packing process to achieve higher efficiency?

☐ **Price:** Which materials meet all the requirements listed above for the lowest cost? Does this include the cost of original materials, costs for validation and testing, efficiencies in fulfilling orders, and how many times the materials can be reused?

☐ **Purpose-designed:** Have all the materials and pack-outs been designed specifically for storing blood products bedside near the patient? Does this design include advanced insulation technology and innovative pack-out design to increase capacity, extend storage duration, reduce wastage and lower total cost?

☐ **Integrated system from a single source:** Do all the materials belong to an integrated, turnkey system from one vendor?

☐ **Flexibility:** Does the system provide all the components necessary to successfully package every type of blood product?

☐ **Pre-validation:** Does the system carry its own pre-validation report to save buyer’s time and money on evaluation and compliance?
MAXQ is an advanced materials R&D firm that has reconsidered the requirements of today’s blood banks and hospitals, and created a turnkey system of blood transport and storage materials that provide better efficiency, simpler compliance, and lower overall costs.

**Overall Considerations**

Many considerations in the checklists are the same for both blood banks and hospitals, including the following. A note on the capabilities of MAXQ’s advanced packaging is included for each item.

**Capacity:** How many units of blood can be carried? Does the cooler capacity meet the requirement for transfusion protocol?

*MAXQ provides the highest usable volume per dimensional weight, with unmatched payload-to-size efficiency.*

**Weight:** What is the weight when fully assembled with cooling materials and blood products?

*MAXQ has designed every element of the system for optimized dimensional weight to reduce all shipping and packaging costs per unit.*

**Cooling materials:** Are payload-specific cooling materials included in the packaging system?

*MAXQ’s turnkey systems include optimized temperature control agents for unprecedented thermal performance. Test results are available on request.*

**Price:** Which materials meet all the listed requirements for the lowest cost? Does this include the cost of original materials, shipping costs for total system including payload, and how many times the materials can be reused?

*When factoring in every item that contributes to overall costs (packaging + shipping + product wastage + compliance), MAXQ provides the lower costs per unit shipped or stored.*

**Purpose-designed:** Have all the materials and pack-outs been designed specifically for transporting blood products? Does this design include advanced insulation technology and innovative pack-out design to increase capacity, extend shipping duration, and lower total cost?

*Yes, from MAXQ.*

**Integrated system from a single source:** Do all the materials belong to an integrated, turnkey system from one vendor?

*Yes, from MAXQ.*
**Flexibility:** Does the system include all the components necessary to successfully package a particular type of blood product?

Yes, from MAXQ.

**Pre-validation:** Does the system carry its own pre-validation report to save buyer’s time and money on evaluation and compliance?

Yes, every item in the MAXQ product line has been pre-validated to save you time and effort in testing and compliance.

**Special considerations for blood banks**

The following considerations apply specifically to blood banks.

**Shipping duration:** How long will the packaging system keep the correct temperature?

MAXQ provides longer temperature hold time, as documented in repeated testing. Test results are available on request.

**Durability:** Can the cold box survive the normal shocks and impacts it will be exposed to?

All cold boxes have been rigorously pre-qualified for consistent pack-out performance with high durability.

**Method of transport:** Is the packaging suitable for transport by blood bank fleet, volunteer drivers, door-to-door specialty couriers, or third-party logistics providers such as UPS or Fedex?

Yes, MAXQ’s system is suitable and cost-effective for all methods of transport.

**Product Wastage:** Does the cold transport system reduce costly wastage of blood and blood products?

Yes, current MAXQ customers report reduced blood product wastage, with zero losses to date.
Special considerations for hospitals

The following considerations apply specifically to hospitals.

**Storage duration:** How long will the packaging system keep the correct temperature? Has this been pre-validated by the supplier to save steps in validation?

*MAXQ provides the longest temperature hold time, as documented in repeated testing. Test results are available on request. Pre-validation documents are provided to save time and effort in validation.*

**Time to pack and issue coolers:** Are there any special pre-conditioning steps involved before issuing a cooler (e.g. thawing gel packs)?

*Not with MAXQ, which does not use gel packs or any other materials that require pre-conditioning. This saves time and streamlines delivering blood products for transfusion.*

**Pack-out consistency:** How consistently can the cold box be packed by lab technicians? How consistently does it avoid seasonal product loses due to changes in ambient environment?

*Lab technicians appreciate how the purpose design of the MAXQ system aids them in consistent packing. MAXQ provides simple step-by-step pack-out instructions, the pack-out assembly ensures highly consistent payload temperatures for a long duration, as documented in repeated testing. Test results are available on request.*

**Pack-out validation:** How efficiently can the cold box be validated for consistent performance?

*Every package from MAXQ includes pre-validation reports, which dramatically reduce the effort required for in-hospital testing. Sample validation reports are available on request.*

**Pack-out simplicity:** Does the system simplify and eliminate steps within the packing process to achieve higher efficiency?

*Yes, every element in MAXQ’s system has been designed specifically to streamline the packing process and reduce time and effort.*

**Product Wastage:** Does the cold transport system reduce costly wastage of blood and blood products?

*Yes, current MAXQ customers report reduced blood product wastage, with zero losses to date.*
Blood and blood products are costly, and inadequate blood transport and storage systems can lead to significant losses.

There are 7 possible points of failure in the blood supply chain where any delays, miscommunications, or procedural issues can cause serious problems.

Yet blood banks and hospitals mainly use cardboard boxes lined with polystyrene insulation, or molded plastic coolers from consumer vendors. These grocery-market coolers are not designed for precise temperature-control and consistent pack-out performance.

To provide a better solution, MAXQ has developed a completely validated cooler transport system. MAXQ materials provide the best operational results, pre-validation documentation to save time and effort in testing, and lower costs per unit shipped or stored.

To find out more about how MAXQ can streamline packing and storage blood products, reduce your compliance headaches, and save costs, contact 405-466-5629 or sales@packmaxq.com today.
Through proprietary breakthroughs in material sciences, MAXQ is revolutionizing the transportation of temperature-sensitive biologics and blood products, eclipsing existing methods in terms of safety, efficiency, and total value.

Our proprietary MAXIFY™ technology spans:

• Revolutionary, patented, thermal insulation composite materials used in our shipping systems to deliver unprecedented thermal insulation efficiency, strength, lightweight benefits, and more

• A new category of zero bench time, payload-specific thermal packaging design solutions employing user-centric ergonomic product engineering made possible only through technological material advancements

Because of MAXIFY’s patented bi-functional material, low thermal conductivity, and high structural rigidity, more materials can be packed and shipped in smaller boxes, retain compliant temperatures over longer periods, arrive with greater quality assurance, and be reused. Our deep scientific and industry experience empowers us to understand and fulfill customers’ complex needs from a knowledgeable “insider” perspective, and with high-value, specialized benefits.

As a result, MAXQ clients can expect unprecedented value through the combination of proven total financial savings, reduced waste, increased workflow efficiencies, enhanced compliance, and the overall integrity of their process, contents, and container—delivering confident peace-of-mind in knowing the advanced quality with which their important, time-sensitive biologics are shipped. All MAXQ products are designed and manufactured in the United States.

For more information, visit www.packmaxq.com
References


