Apheresis technologies: procedures and equipment for selective target removal

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Topics of presentation

- **Historical aspects**
- Definition
- Principle technologies used in apheresis
- Application in therapeutic apheresis
- Instruments for therapeutic apheresis
- Systematization
- Hazards and risk control
PLASMA REMOVAL WITH RETURN OF CORPUSCLES
(PLASMAPHÆRESIS)

FIRST PAPER

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From the Pharmacological Laboratory of the Johns Hopkins University

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I. In connection with our experiments on vividiffusion with a view to the ultimate use of the method for the relief of toxæmia the idea suggested itself to try the effects of the repeated removal of considerable quantities of blood, replacing the plasma by Locke's solution and reinjecting this together with the sedimented corpuscles.

While this work was in progress our attention was called to an article in a recent number of Russki Vratch (No. 14. pp. 637–639, St. Petersburg, May 16, 1914); by V. A. Yurevitch and N. K. Rosenberg, entitled: Washing the Blood Outside the Organism and the Survival of the Red Corpuscles, in which experiments similar in general outline to our own are reported. The authors worked on rabbits, using sodium citrate to obviate clotting. Only about 50 per cent of the blood volume was withdrawn (carotid) and the washed corpuscles reinjected. In two experiments a second amount of blood, about half as great as the first was withdrawn to show by the survival of the animal that the corpuscles reinjected were physiologically active.

The fact that washed corpuscles obtained from one animal can be introduced into another animal of the same species (dogs) and function naturally for a number of days at least, also follows from the experiments made by P. Morawitz in the course of his studies on the restoration of the proteids of the blood, although no blood counts are given (Beitr. z. chem. Physiol u. Pathol., vii, 150, 1906).

Boruttau Nagel's, Hdb. der Physiol. des Mensch. Erginzungsband, p. 32, 1910) states that the centrifuged corpuscles of desfibrinated
Primary reports on plasmapheresis treatment

FIG. 3. The subjects of the primary reports on therapeutic plasmapheresis between 1952 and 1980, together with their lead authors, are shown (48,49) (reprinted with permission from ISAPO Press).

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Apheresis

aphaerese, aphaeresis

• The term comes from the Greek / Latin language
• Aphaeresis means remove, extraction

The term "Apheresis" describes all methods for the (extracorporeal) removal of substances from the body.

"Apheresis" means the withdrawal or removal of substances mainly blood components from the body and could understand as a blood purification system.
Extracorporeal procedures

- Withdrawal of body-own liquids (blood) from the body
- Removal and/or modification of body liquid composition by physico-chemical means.
- Return of the total or a part of the body-own liquids into the body
Apheresis - a method of blood purification

- Apheresis: Separation, extraction
- Therapeutic apheresis describes extracorporeal blood purification methods, which are not for organ replacement.
- The methods of therapeutic apheresis use filters, adsorbers or other physically systems.
- The goal of the apheresis treatment is the elimination of substances, which play an important role in the illness.
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Basic technologies for plasma separation

Membrane separation

Separation by size selection on a membrane

Centrifugation

Separation by specific weight in an artificial gravitation field

Blood → Plasma → Cells

Blood → Plasma → Cells

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plasma line

membrane
pore size 0.5 µm

blood line

molecular weight (Dalton)

erythrocyte

protein 60,000-4,000,000
high flux up to 30,000

vitamin B12 1,355
uric acid 168
creatinine 113
urea 60
potassium 39
sodium 22
Basic technologies for plasma separation

Separation Mechanism of PE

Whole blood from patient
Plasma separator
Separated plasma
Substitution fluid
Blood returned to patient

Cross section
Inside (Blood contact)

Cross section
Outside
Basic technologies for plasma separation

The scanning electron microscopy findings of cross-sectional structure of PES. The cross-section structure of PES has an asymmetric three-layer structure having a compact layer with fine pore size on the inside and outside of the hollow fiber as well as a support layer in the central part thereof.

The challenge:
Wall thickness 30 ...60 µm
Blood cell 2 … 12 µm
Large plasma particle 0,1 ...1 µm

Takaya Abe,1,* Karen Kato,1 Tomoaki Fujioka,1 and Tadao Akizawa2
The Blood Compatibilities of Blood Purification Membranes and Other Materials Developed in Japan
- Separated plasma will be discarded
- Discarded plasma has to be substituted by albumin solution or fresh (frozen) plasma

Other terms:
- (therapeutic) plasmapheresis
Plasma Exchange Circuit – Centrifuge
Plasma separation - Plasma exchange Devices

Membrane plasma separation device

Excorim PEM 10

Centrifuges

Cobe spectra

Cobe trima
Plasma is collected by filtration from whole blood by the Separator, a sterile single-use device for exclusive use with the LIFE 18®. Plasma separation takes place at the filter membranes through control of the transmembrane pressure. The blood volume in the disc separator is approximately 10 ml.
Advantages / Disadvantages
Membrane Plasma separation

- **Advantages**
  - Plasma practically cell free
  - Simple to operate
  - Simple instruments required; similar to hemofiltration devices used in CRRT

- **Disadvantages**
  - Extreme large artificial surface that is in contact with plasma
  - Limited permeability for very large plasma components (e.g. chylomicrons)
  - Limited plasma volume harvested from the blood (30%)