Water Metabolism after Cardiac Operations Involving a Gibbon-Type Pump-Oxygenator

II. Benign Forms of Water Loss

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Each of 21 patients was noted to have a low concentration of water in the serum immediately after whole-body perfusion. This indicated a loss of water either by the patient or the pump-oxygenator. Investigation suggested that the patient, and not the pump-oxygenator, was the source of water loss. Two of the 21 patients had a profuse, short-lived solute diuresis in the immediate postperfusion period. These phenomena are apparently benign and they require no specific treatment.

During the study of a group of patients who had undergone cardiac operations involving whole-body perfusion, 2 unusual types of water loss were noted. One type, water loss during operation, was observed in each of the 21 patients. The other type, renal water loss, was observed in 2 of the 21 patients.

The materials, methods, and calculations used in this paper are similar to those employed in a preceding one.1

Water Loss during Operation

It was noted in each of the 21 patients studied that the concentration of water in the serum was very low after perfusion (fig. 1). Since the patients had no opportunity to gain solute during operation, it seemed likely that the low values for serum water content were due to rather sizable water losses during operation.

Accordingly, the Gibbon-type pump-oxygenator was investigated to see if it was a source of water loss. The machine was operated for 2 hours under conditions simulating the perfusion of a patient; blood samples were withdrawn from it every 15 minutes and the osmolarity of the serum was determined (fig. 2). The serum water concentration was calculated and it varied insignificantly during this 2-hour run. This study suggested that the pump-oxygenator was not an important source of water loss.

Next, the serum water concentration was determined at intervals during the course of operation in 1 patient (fig. 3). All samples were withdrawn from a catheter in the femoral artery. The patient received only a few milliliters of water during operation. Blood losses were recorded carefully and were replaced with equal volumes of blood. Figure 3 illustrates that the patient's serum water content was within the physiologic range at the onset of operation. It decreased steadily throughout the procedure. The figure also shows that the blood in the pump-oxygenator had a normal water content before perfusion, but that the content had fallen considerably at the end of perfusion. The steady decrease in serum water concentration during operation, but before perfusion, is strong evidence of a large water loss from the patient's plasma. This loss did not occur through the kidneys since the volume of urine during operation was small. Also the small volume of urine was offset by the small amount of dextrose in water solution given intravenously during operation. By exclusion, it seems reasonable to suggest that the water loss from the patient's plasma and the machine's plasma during operation was almost entirely insensible water loss.

Measurements of insensible water loss of postoperative patients similar to this one revealed a mean insensible water loss in the first 3

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postoperative days of 406 ml per M.2 per day.\textsuperscript{1} It appears that the insensible water loss (calculated as ml. per M.\textsuperscript{2} per 1 hour) during operation is much greater than that in the postoperative period. It is proposed that this greater insensible water loss during operation occurred predominantly from the moist, exposed pleural and pericardial surfaces while the usual insensible water loss via the skin was unchanged in amount.

Ruzic\textsuperscript{3} subjected anesthetized dogs to a 2-hour abdominal operation during which he laid the small intestine out on sterile drapes and attempted to expose maximally to the air the mesentery and peritoneum. By weighing the dogs before and after operation he was able to estimate the insensible water loss; he found this loss to be 2 to 3 per cent of the body weight. His data and ours suggest that the moist serous surfaces within the thorax and abdominal cavities lose considerable amounts of water when exposed to room air.

The serum water concentration returned to the normal range in less than 12 hours in most cases (figs. 1 and 4). This occurred even in patients in striking negative water balance (fig. 4). In these cases, it appears that water from intracellular sources may become available to restore the serum water to more nearly normal levels.

No attempt was made to increase the amount of intravenous water during the first 24 post-

FIG. 1. The low concentration of water in the serum at the end of perfusion is evident. There was, however, a rapid return to the normal range 6 hours after perfusion while the water input was minimal. Concentration is in terms of milliliters of water per milliosmol of solute.

FIG. 2. These data were collected from the blood in a Gibbon-type pump-oxygenator during a 2-hour run under conditions simulating the perfusion of a patient. The steady water-solute ratio suggests that the pump-oxygenator is not an important source of water loss.

FIG. 3. The patient's serum water decreased steadily until the initiation of perfusion. The serum water of the patient and the pump were in equilibrium at the end of perfusion. Thus, the patient probably gained water from the pump's blood during perfusion.

FIG. 4. The concentration of serum water returned to normal in 6 hours although the patient was in negative water balance.
operative hours in order to correct the low serum water content. It corrected itself in 20 of the 21 patients. We have come to regard this phenomenon of increased water loss during operation as benign, since no deleterious effects could be attributed to it. It is conceivable that this water loss might have been beneficial to these rather ill cardiac patients.

RENAL WATER LOSS

Two patients excreted large volumes of urine during the first 11 hours of study (figs. 5 and 6). In each instance most of this volume was excreted between 5 and 11 hours after the start of operation; this was 1 to 6 hours after perfusion. These specimens of urine consisted mostly of obligatory urine water. It might be said that a short, profuse solute diuresis occurred. Figures 5 and 6 show that each patient reverted to the usual pattern of excretion of urine water and solute after the eleventh hour of study.

SUMMARY

Data are presented which suggest that the insensible water loss was strikingly increased during cardiac operations involving extracorporeal circulation. It is believed that this loss occurred mostly from the exposed, moist pleural and pericardial surfaces. The Gibbon-type pump-oxygenator was not found to be a source of water loss.

Two cases are presented in which a short, profuse solute diuresis occurred in the immediate postperfusion period. The solute was accompanied by a large volume of water. This condition was short-lived. We regard these 2 phenomena as benign sequelae of this type of operation. No efforts were made to correct them and no untoward effects were observed.

SUMMARIO IN INTERLINGUA

Es presentate datos que suggere que le perdita insensible de aqua es frappantemente augmentate durante operationes cardiac que utilisa un circulation extracorporee. Es opinate que iste perdita occurre principalmente ab le exponite e humide superficies pericardial e pleural. Non essea trovate que le pumpa-oxygenator del type Gibbon es un causa de perdita de aqua.

Es presentate duo casos in que un breve e profuse diuresis de soluto occurreva durante le periodo immediatemente postperfusional. Le
There was a young man in Boston town,
He bought him a stethoscope nice and new,
All mounted and finished and polished down,
With an ivory cap and a stopper too.

It happened a spider within did crawl,
And spun him a web of ample size,
Wherein there chanced one day to fall
A couple of very imprudent flies.
The first was a bottle-fly, big and blue,
The second was smaller, and thin and long;
So there was a concert between the two,
Like an octave flute and a tavern gong.

Now being from Paris but recently,
This fine young man would show his skill;
And so they gave him, his hand to try,
A hospital patient extremely ill.

Some said that his liver was short of bile,
And some that his heart was over size,
While some kept arguing, all the while,
He was crammed with tubercles up to his eyes.
This fine young man then up stepped he,
And all the doctors made a pause;
Said he, The man must die, you see,
By the fifty-seventh of Louis's laws.

But since the case is a desperate one,
To explore his chest it may be well;
For if he should die and it were not done,
You know the autopsy would not tell.

Then out his stethoscope he took,
And on it placed his curious ear;
Mon Dieu! said he, with a knowing look,
Why, here is a sound that's mighty queer!

The bourdonnement is very clear,—
Amphoric buzzing, as I'm alive!
Five doctors took their turn to hear;
Amphoric buzzing, said all the five.

There's empyema beyond a doubt;
We'll plunge a trocar in his side.
The diagnosis was made out,—
They tapped the patient; so he died.

Now such as hate new-fashioned toys
Began to look extremely glum;
They said that rattles were made for boys,
And vowed that his buzzing was all a hum.

There was an old lady had long been sick,
And what was the matter none did know;
Her pulse was slow, though her tongue was quick;
To her this knowing youth must go.

So there the nice old lady sat,
With phials and boxes all in a row;
She asked the young doctor what he was at,
To thump her and tumble her ruffles so.

Now, when the stethoscope came out,
The flies began to buzz and whiz;
Oh ho! the matter is clear, no doubt;
An aneurism there plainly is.

Now, when the neighboring doctors found
A case so rare had been descried,
They every day her ribs did pound
In squads of twenty; so she died.

The poor young man was all aghast;
The price of stethoscopes came down;
And so he was reduced at last
To practise in a country town.

The doctors being very sore,
A stethoscope they did devise
That had a rammer to clear the bore,
With a knob at the end to kill the flies.

Now use your ears, all you that can,
But don't forget to mind your eyes,
Or you may be cheated, like this young man,
By a couple of silly, abnormal flies.

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