# Early Detection of Renal Failure After Cardiopulmonary Bypass

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The early diagnosis of renal failure is not likely to be made often because the clinical signs and the commonly used laboratory procedures have been of little value unless renal failure was well established.[1] The need for a reliable, quick, and easy method to predict or detect impairment of renal function early in its course is obvious. Early detection would permit the study of the causative factors implicated in the development of renal failure in the individual patient in time to be of benefit to him. It has been calculated that a sampling of 30,000 patients is needed to establish a significant statistical proof of the efficacy of a therapeutic agent upon renal failure.[2] Data will be presented to show the value of frequent determinations of urinary urea concentration to detect and predict impairment of renal function after cardiac surgery and cardiopulmonary bypass. An equation has been developed in which the urinary urea concentration is employed to obtain a quite accurate measure of the glomerular filtration rate.

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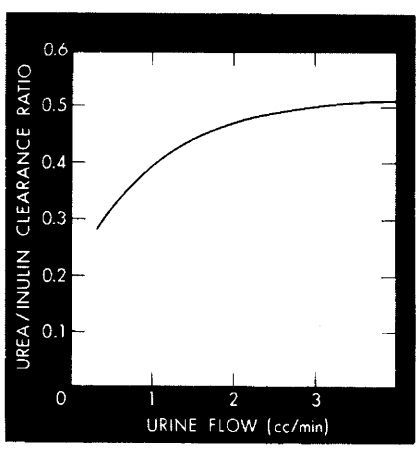
## Methods

Urinary urea determinations were performed at frequent intervals during and after cardiopulmonary bypass in seven patients undergoing intracardiac surgery. The heart-lung machine incorporated a disk oxygenator and was primed with a mixture of Edglugate blood and dextran 40; flows during bypass were kept at 2.4 liters/sqm/min.

Fig 1.—Relationship between urinary flow and ratio of urea clearance-inulin clearance (from data of Smith[3]).




Blood urea content determinations were done before, during, and after bypass operation and daily thereafter. Blood urea concentration was determined by Rosenthal's (diacetylmonoxime) method. The urine was diluted 1:20, and the urea concentration was determined by the method mentioned. The rate of urine flow was recorded every 30 minutes during bypass and every hour postoperatively.

**Origin of the Equation to Determine Glomerular Filtration Rate (GFR).**—The GFR can be expressed as the urea clearance divided by the urea-inulin clearance ratio. The urea-inulin clearance ratio as related to urinary flow was taken from Fig 1, constructed with some modifications for less than 2 ml/min of urinary flow from the data obtained by Smith.[3] The GFR was calculated as follows: The urinary urea-blood urea ratio was divided by the urea-inulin clearance ratio (obtained from Fig 1) and the result was multiplied by the urinary flow in milliliters per minute.

$$\text{GFR, ml/min} = \frac{\text{urinary urea-blood urea}}{\text{urea-inulin clearance ratio}} \times \text{urinary flow, ml/min}$$

This equation takes into account the dependence of urea clearance on urine flow when the latter is less than 2 ml/min and makes it possible to express urea clearance as glomerular

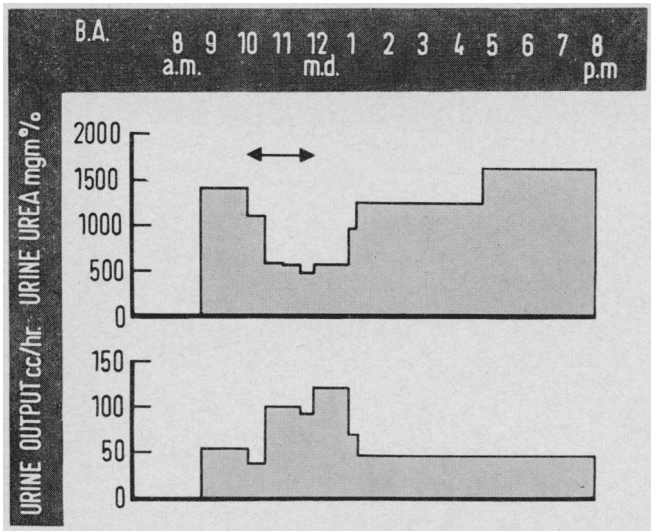



Fig 2.—Marked drop in urinary urea concentration during cardiopulmonary bypass. Postbypass rise in urinary urea concentration with levels above prebypass eight hours after operation.

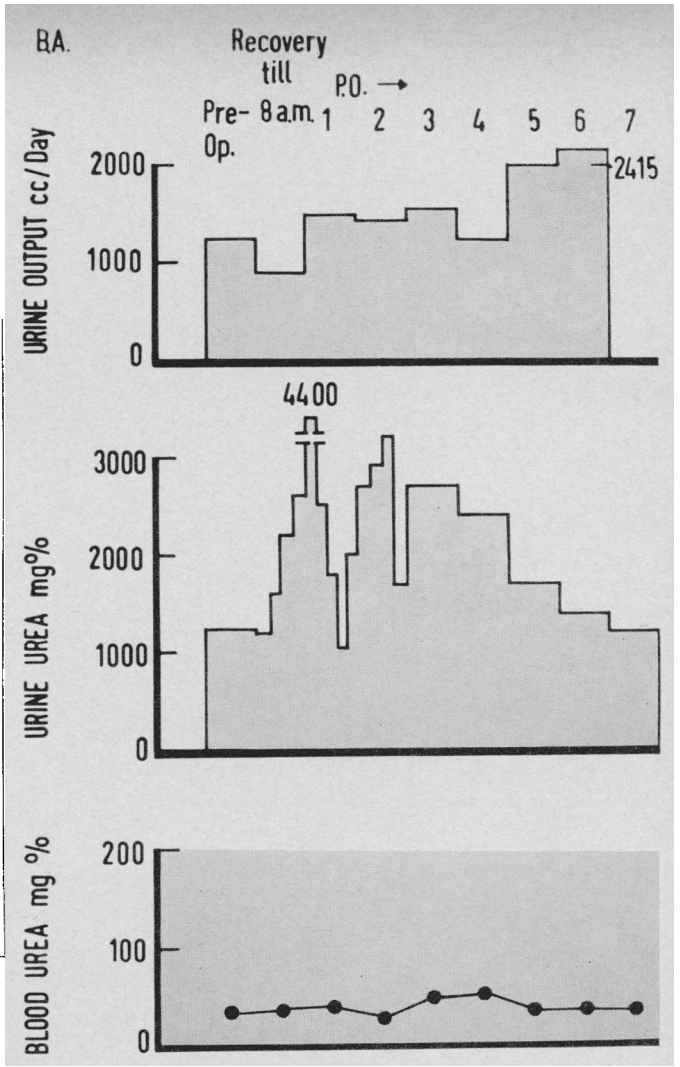



Fig 3.—Urinary urea concentration rose to 4,400 mg/100 ml in the morning of first postoperative day. Note temporary drop during paroxysmal auricular fibrillation on first postoperative day.

filtration rate when the values of the urinary urea-blood urea ratio will depend on rapid changes in urinary urea concentration.

## Results

A marked fall in urinary urea concentration was observed in all patients during cardiopulmonary bypass; the lowest values were obtained at the end of bypass. After discontinuance of the bypass, the urinary urea concentration rose rapidly to greater than prebypass levels in the patients who had normal blood urea concentration postoperatively. The rise in urinary urea concentration was slow in the patients whose blood urea values ranged from 70 to 150 mg/100 ml postoperatively but who had no clinical manifestations of uremia or oliguria. In one patient in whom oliguric renal failure developed, the urinary urea concentration did not rise following bypass.

Preoperative values of urinary urea concentration ranged from 2,600 to 925 mg/100 ml with an average of 1,526 mg. During bypass they ranged from 550 to 200 mg/100 ml with an average of 410 mg. At 8 PM of the day of operation urinary urea values ranged from 330 to 1,800 mg/100 ml with an average of 1,097 mg/100 ml, and at midnight they ranged from 2,200 to 365 mg/100 ml with an average of 1,390 mg/100 ml. At 8 AM of the first postoperative day they ranged from 2,600 mg/100 ml to 300 mg/100 ml with an average of 1,455 mg/100 ml.

The highest blood urea value in these patients was noted between the second and fifth postoperative days and it ranged from 52 to 260 mg/100 ml.

The highest blood urea values correspond well with a lower urinary urea concentration after cardiopulmonary bypass.

The results in seven patients with urinary urea studies before, during, and after cardiopulmonary bypass for repair of intracardiac lesions are summarized in the Table. A significant negative correlation was observed between the highest postoperative blood urea value and the urinary urea concentration at 8 AM ($r = 0.867$, $P < 0.01$).

Figures 2 and 3 show results of the complete study in a patient who underwent aortic valve replacement. The usual drop in urinary urea concentration was followed by a stepped up rise during the postoperative period when the urea level reached 4,400 mg/100 ml in the first postoperative day. A temporary drop occurred during an episode of paroxysmal atrial fibrillation.

The blood urea levels remained between normal limits and the highest value of 52 mg/100 ml was noted on the fourth postoperative day. The urinary output during the first four postoperative days did not change appreciably.

Figures 4 and 5 show data from the complete study in a patient who underwent aortic valve replacement