The problem of catheter encrustation

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Summary: Catheter encrustation was studied in a group of long-stay hospital patients using both latex and silicone catheters. Moisture accounted for 80% by weight of the encrusted material with both catheters. Of the dry weight 90% was composed of protein, calcium, phosphorus, magnesium and uric acid. No relationship was found between the amounts of these substances in the urine and in the encrusted material. High levels of calcium, phosphorus and magnesium were found in the encrusted material from patients infected with *Proteus* organisms. No direct relationship was found between the duration of catheter drainage and the degree of encrustation, and there was a variation in patient susceptibility to encrustation irrespective of the catheter material. There was significantly less encrustation associated with silicone catheters.

Résumé: *Le problème de l'incrustation des cathéters*

Nous avons étudié le problème de l'incrustation des cathéters chez un groupe de malades hospitalisés depuis longtemps et qui étaient porteurs de sondes en latex et en silicone. La substance incrustée, dans les deux types de cathéters, comportait en poids, 80% d'eau. Quant au poids à sec, 90% était composé de protéine, de calcium, de phosphore, de magnésium et d'acide urique. Il n'a pas été possible d'établir une relation entre les quantités de ces substances dans l'urine et la substance incrustée. On a noté de fortes concentrations de calcium, de phosphore et de magnésium dans la substance incrustée chez les malades souffrant d'infections par des organismes du genre *Proteus*. On n'a pu établir de relation directe entre la durée du drainage par sonde et le degré de l'incrustation. De plus, on notait des variations dans la sensibilité du malade à l'incrustation, indépendamment de la nature de la matière dont était fait le cathéter. Cependant, on remarquait une incrustation nettement moindre chez les malades porteurs d'un cathéter en silicone.

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Much has been written in recent years on the subject of catheter care and the prevention and control of urinary tract infection when indwelling catheters are used. In addition, there has been a marked improvement and refinement in the materials used in making catheters. Despite these advances, encrustation and the formation of bladder calculi is still a problem with patients on long-term indwelling catheter drainage. Encrustation attending the use of the more inert catheter materials now available has received relatively little attention, although there have been articles advocating the use of Renacidin® and methylene blue in prophylaxis.[1,2] Barnhouse[3] in 1968 reported his experience with formation of *in vitro* precipitates on foreign bodies in sterile and infected urines and found that, apart from the influence on pH, bacteria did not directly affect crystallization in urine. In 1972 Srinivasan and Clark[4] reported their study comparing encrustation *in vitro* with different catheter materials; they found less encrustation with plastic and silicone than with latex and teflon in both sterile and infected urines. Painter *et al*,[5] in a study of mucosal reaction to different catheter materials, found less reaction to teflon and silicone-coated latex, and at the 1973 American Urological Association meeting they reported the pure silicone catheter to be even less reactive.

We have had the opportunity to study catheter encrustation in two groups of long-staying patients in a chronic care hospital. The 20 patients of the first group were submitted to equal periods of drainage by both a latex and pure silicone catheter, then the weight and calcium content of the encrustation were determined. The second group of 14 patients was studied in the same manner but detailed analysis of the encrusted material was carried out. The purposes of the study were: (a) to show the difference in degree of encrustation with silicone and latex catheters; (b) to identify the composition of the encrusted material; and (c) to study the factors responsible for the encrustation.

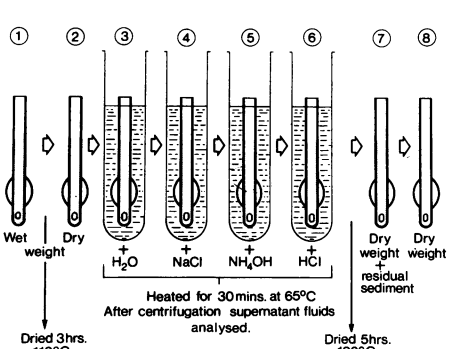

FIG. 1—Diagrammatic illustration of methodology used to identify encrusted material in silicone and latex catheters.

Methods

The following studies were carried out: urinalysis and culture of urine; and chemical analysis of blood, 24-hour urine samples and catheter encrustation.

For detailed analysis segments of catheters with encrusted material were weighed in the wet and dry state and then washed in several solutions, distilled water, saline 0.9%, ammonium hydroxide 10% and hydrochloric acid 5%, heated for 30 minutes at 65°C and centrifuged. The supernatants were analysed for protein, calcium, phosphorus, magnesium, uric acid, sodium, potassium, chloride, creatinine and urea nitrogen. The dry weight of the catheter plus the residual sediment was ascertained, as well as the dry weight of the catheter after the sediment had been scraped off (Fig. 1).

Results

All patients studied had alkaline urine and all cultures grew multiple

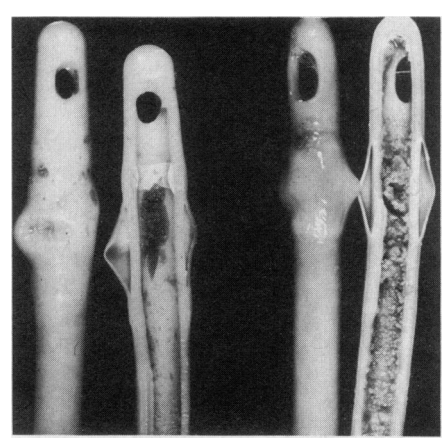

FIG. 2 — Typical difference in degree of encrustation between silicone and latex catheters after equal periods of use.

organisms. No antibiotics were administered during the study.

Group 1

Fig. 2 illustrates the marked difference in degree of encrustation between a latex and a silicone catheter after equal periods of use in the same patient. Although the duration of drainage varied widely in this group, in each patient it was identical for the two types of catheter. Fig. 3 shows the relative weights of encrusted material in the two types of catheter and the number of days each catheter was in place. Three points would appear significant:

1. The weight of encrusted material is significantly greater with the latex catheter.
2. There is no direct relationship between the duration of catheter drainage and the degree of encrustation.
3. Irrespective of catheter material there is a marked variation in patient susceptibility to encrustation.

The calcium content of the encrustation was also much higher for the latex catheters (Fig. 4).

Group 2

In this group each patient had undergone a two-week period of drainage with each type of catheter. Moisture accounted for 80% of the weight of the encrusted material in both silicone and latex catheters (Fig. 5). The mean weight of encrusted material was significantly greater with the latex catheters.

Fig. 6 compares the mean dry weights of encrusted material and the proportions of material identified. Approximately 30 to 40% of the dry material was eluted by the methodology used, so that about 12% by total weight of the encrusted material remained unidentified. The relative proportions of the different materials identified in the dried encrustation are shown in Fig. 7; protein, calcium, phosphorus, magnesium and uric acid formed approximately 90% of the total identified dry weight, and sodium, potassium, chloride, creatinine and urea nitrogen made up the remaining 7 to 10%. There appears to be no great variation in the relative proportions of these constituents with the two catheter materials. Their mean weights are shown in Fig. 8. Again, the larger absolute weights of these substances are associated with the latex catheters. It is interesting to note that the relative proportions of protein, magnesium and uric acid are approximately equal with the two types of catheter, but the calcium and phosphorus proportions are disproportionately high with the latex material.

It is said that one factor influencing the amount of encrustation is the solute content of the urine. In this study we could find no correlation between the amounts of calcium, phosphorus, magnesium and uric acid in the urine and in the encrusted material. However, Fig. 9 shows a linear relationship between the relative concentrations of protein in the encrustation and urine with both types of catheter, particularly the silicone.

Proteus organisms were cultured in seven of the fourteen patients, and in six of the seven, high levels of calcium, phosphorus and magnesium were found in the encrustation. Presumably the urea-splitting property of the organisms is a factor in the precipitation of these inorganic substances.

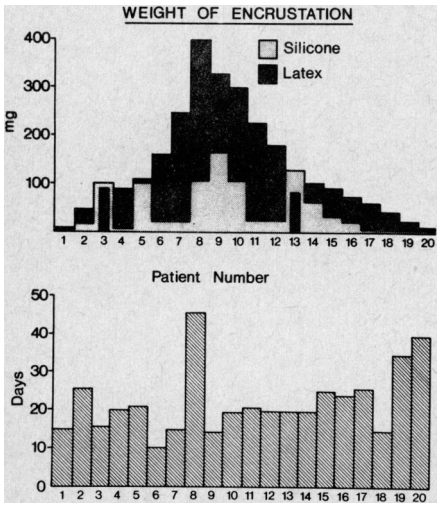

FIG. 3—Relative weights of encrusted material in silicone and latex catheters and number of days each type of catheter was in place.

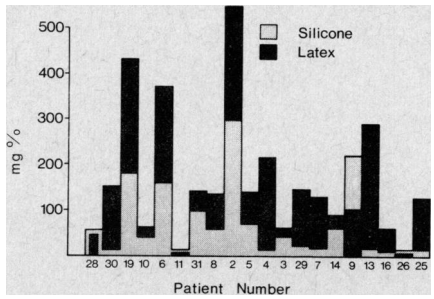

FIG. 4—Relative weights of calcium in silicone and latex catheters after equal periods of drainage.

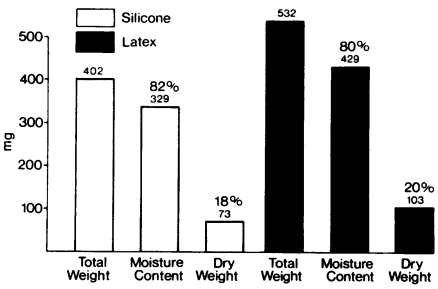

FIG. 5—Total mean weight, moisture content and dry weight of encrusted material in silicone and latex catheters.

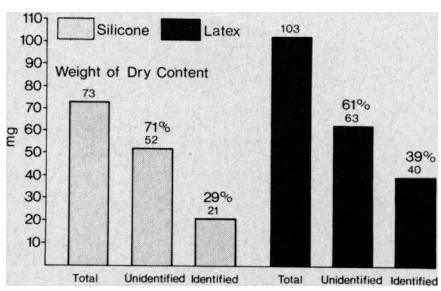

FIG. 6—Mean weights ot unidentified and identified material composing dry encrustation in silicone and latex catheters.

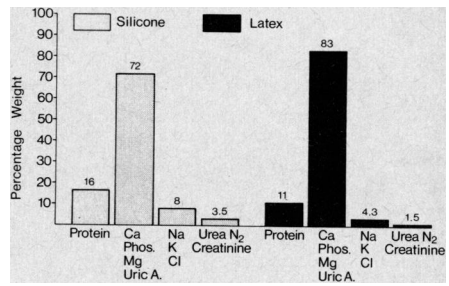

FIG. 7—Mean proportions of major identified constituents of dry encrustation.

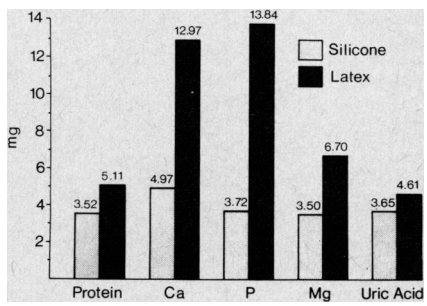

FIG. 8—Mean weights of major identified constituents of dry encrustation in silicone and latex catheters.

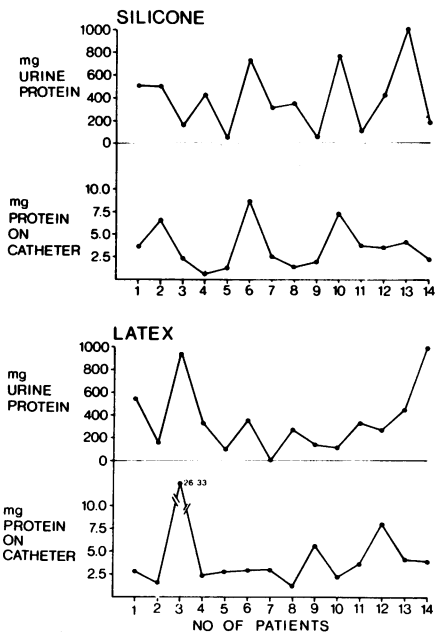

FIG. 9—Correlation of protein content of urine (24-hour sample) and encrusted material in silicone and latex catheters.

Discussion and conclusions

The results of our *in vivo* studies agree with those of the *in vitro* studies of Srinivasan and Clark.[4] Encrustation is less likely to occur with silicone catheters than with latex catheters. Although this study was carried out in a series of patients with infected urine, it is believed that this would also apply to patients with sterile urine. It would seem reasonable to suggest that for long-term catheterization silicone has advantages over latex.

Possible explanations for the superiority of the silicone catheter are as follows: (1) the smooth, nonsticky surface reduces the adsorption of material to, and its absorption by the catheter; (2) the inert material produces less mucosal reaction; and (3) the lumen is larger.

Our methodology failed to identify 12% of the total encrustation. This proportion may consist of (a) cellular material (not appearing as protein), (b) denatured protein, and (c) other chemicals such as trace metals, e.g. zinc.

The absence of any relationship between duration of catheter drainage and degree of encrustation supports the concept of Howard *et al*[6-8] of inhibitors in the urine, and we suggest they may be a defence against encrustation on a foreign body. This situation is comparable to that of stone-formers and non-stone-formers who have similar urinary calcium concentrations. In this study inhibitors of urinary deposits, such as orthophosphates and citrate, were not measured.

We intend to carry out further studies with similar patients to establish the mode of formation of the encrustation and to attempt a more complete chemical analysis.

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