

HIGH LEVELS OF SECRETORY IgA AND FREE  
SECRETORY COMPONENT IN THE SERUM OF RATS  
WITH BILE DUCT OBSTRUCTION\*

By ISABEL LEMAITRE-COELHO, GRAHAM DOUGLAS FISHER JACKSON, AND  
JEAN-PIERRE VAERMAN

(From the Unit of Experimental Medicine, International Institute of Cellular and Molecular  
Pathology, Catholic University of Louvain, B-1200 Brussels, Belgium)

Secretory IgA (SIgA) is in majority confined to exocrine secretions, where it represents the predominant immunoglobulin in most mammalian species (1, 2). In humans, SIgA occurs at very low levels in normal serum ( $\cong 1-2\%$  of total IgA), and is increased in a variety of conditions not always clearly involving glandular mucosae (3). The highest levels of SIgA in human serum were observed in lactating women, where the SIgA represented as much as 7% of the total serum IgA. Although usually undetectable in animals, SIgA has been found in serum in a few instances (2, 4, 5), including serum from rats (unpublished observations) with transplantable IgA immunocytoma (6). In contrast, free secretory component (FSC) was never detected in mammalian serum.

It was recently shown that cannulated rat bile contained three major proteins; albumin, SIgA, and FSC (7). The absolute IgA levels in rat bile were higher than were serum levels. Roughly, 10-15 mg each of SIgA and FSC are poured daily into the rat intestine via the bile (7). In another study,<sup>1</sup> we demonstrated that the perfused rat liver is able to actively transfer a rat monoclonal IgA from the circulation into the cannulated bile, against a strong concentration gradient. These findings suggest that obstruction of the bile duct of the rat (which has no gall bladder) may modify the IgA levels of rat serum.

The present report deals with the consequences of bile duct ligation on the immunoglobulin concentrations in rat serum. The study was performed with particular emphasis on IgA.

### Materials and Methods

*Animals.* Male OFA rats ( $200 \pm 20$  g) were used throughout.

*Antisera.* Monospecific antisera against rat IgA, IgM, IgG, albumin, and FSC have been described previously (8, 9).

*Sera.* Sera, obtained from tail-vein blood, were either kept frozen or at 4°C with 0.1% NaN<sub>3</sub>.

*Surgery.* The bile ducts of rats anesthetized with ether were occluded according to the method of Lambert (10). For temporary obstruction, the bile duct was compressed against a 5-mm long plastic tube by two silk knots; 24 h later, the knots were cut and the bile flow was reestablished. The sham operation consisted of a laparotomy and mild manipulation of liver and intestine for about 10 min.

*Immunochemical Methods.* The presence of IgA, SIgA, and FSC in serum was detected by conventional immunoelectrophoresis and Ouchterlony analyses. Quantitative estimations of IgA, IgM, IgG, and albumin in sera were performed by single radial immunodiffusion (11).

\* Supported by grant 1192 from the Fonds de la Recherche Scientifique Médicale, Brussels.

<sup>1</sup> G. D. F. Jackson, I. Lemaitre-Coelho, J. P. Vaerman, H. Bazin, and A. Beckers. Manuscript submitted for publication.

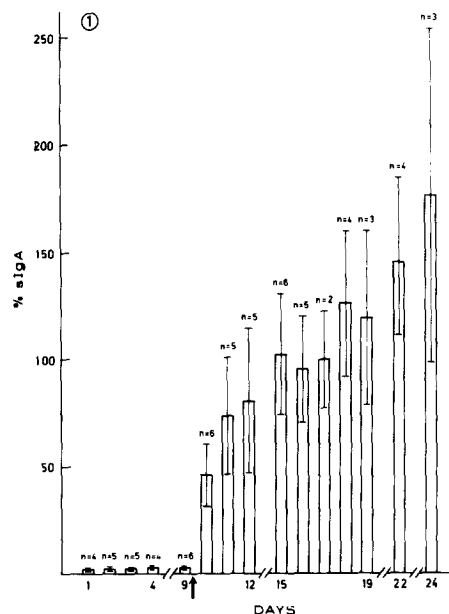


FIG. 1. IgA levels (means  $\pm$  SD) in sera of  $n$  rats at various times before and after ligation (arrow) of the bile duct: 100% = 5.1 mg of IgA/ml (see Materials and Methods).

Levels were expressed as percentages of pooled normal rat serum for IgM, IgG, and albumin, and as percentages of the IgA content of a sample of semi-purified milk SIgA (9) for IgA (100% = 5.1 mg/ml).

**Gel Filtration.** 7 ml of serum from a normal rat, or from a rat under bile duct occlusion for 2 wk, was applied to a  $2.5 \times 90$ -cm column of Ultrogel AcA 22, eluted with 2% NaCl, buffered with 0.02 M Tris-HCl, pH 8.0, and containing 0.1% NaN<sub>3</sub>. Eluates were pooled in several fractions, according to their optical density at 280 nm, which were then concentrated to 1 ml before analysis by agarose-gel electrophoresis (12) and immunoelectrophoresis. The column was calibrated with samples of human IgM, milk SIgA, IgG, and albumin.

## Results

After the ligation of the bile duct of rats, the IgA level in their sera increased rapidly and very strongly (Fig. 1). Within 24 h, the IgA in serum had risen 10- to 20-fold. Thereafter, the IgA concentration in serum continued to increase progressively, until maximal values of 30-100 times those of the preoperative period were reached, just before the animal's death (10-30 days).

The selectivity of these raised levels of IgA in serum was demonstrated by the lack of corresponding changes in the serum levels of IgG, IgM, and albumin (Fig. 2). Also, none of the sham-operated rats displayed any significant alteration in their serum levels of IgA, IgG, IgM, and albumin.

The kinetics of the increase and decrease of IgA in serum after ligation and reopening of the bile duct, respectively, are illustrated in Figs. 3 and 4. When the ligation was maintained for only 24 h, the increased level of IgA persisted for only 1-5 days (Fig. 3). 1 h after ligation, there was already a noticeable increase of the IgA level in serum, which became obvious upon immunoelectrophoresis at 3 h after obstruction (Fig. 4). Antibodies against rat secretory component (SC) revealed that, at all times, increased levels of IgA in serum seemed entirely due to SIgA, as indicated by the parallel intensities of the IgA

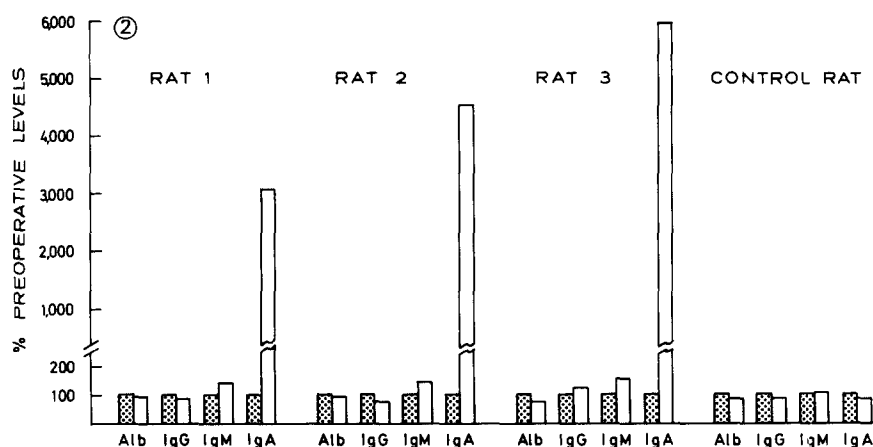


FIG. 2. Serum levels of albumin, IgG, IgM, and IgA in three rats before (dotted columns) and after (open columns) bile duct ligation or sham operation (control). The bile ducts of rats 1, 2, and 3 were ligated for 6, 14, and 28 days, respectively. The control serum was taken 6 days after sham operation.

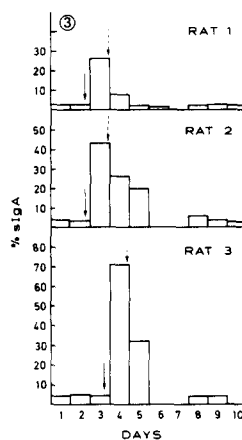


FIG. 3. Levels of IgA in serum of three rats at various times before and after bile obstruction (solid arrow) and reopening (dashed arrow).

and SIgA precipitin lines developed by anti- $\alpha$ -chain and anti-SC antibodies, respectively (Fig. 4). At 3 h after ligation (and occasionally earlier), FSC, easily identified by its rapid anodal mobility, appeared in the serum. The FSC level increased with time after ligation (Fig. 4), but after 2–4 wk of jaundice, the level in serum decreased without the apparent drop of SIgA in serum (data not shown). When the bile duct was reopened after 24 h of obstruction, FSC disappeared from serum within 24 h (Fig. 4).

To confirm that increased IgA levels were due to SIgA, normal rat serum and the serum of a rat whose bile duct had been occluded for 2 wk were submitted to gel filtration on Ultrogel AcA 22 (data not shown). After concentration of the absorbance peaks, two major IgA-containing fractions were found only in the eluates of the jaundiced serum. As for bile, the second of these fractions eluted at the same volume as did 11S human SIgA. The two IgA

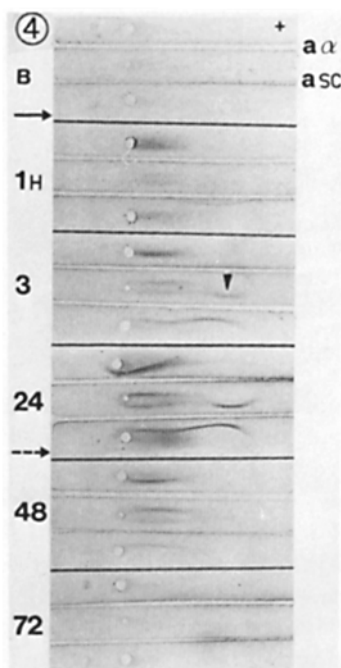


FIG. 4. Immunoelectrophoreses of sera from a rat taken before (B) and at various times (1, 3, 24, 48, and 72 h) after ligation (solid arrow) and reopening (dashed arrow) of the bile duct. Each plate was developed by anti- $\alpha$ -chain ( $a\alpha$ ) and anti-SC ( $aSC$ ) antisera, respectively, in the upper and lower troughs. Note that the concentration of IgA in serum before ligation is so small that no precipitin line is visible, even using a large antigen reservoir. Arrowhead shows FSC.

fractions reacted equally well with anti- $\alpha$ -chain and anti-SC antisera. In addition, FSC was immunoelectrophoretically detected in a fraction from the jaundiced serum eluted between IgG and albumin, as expected. The normal serum fractions showed only weak reactivity with anti- $\alpha$ -chains and no reactivity with anti-SC.

#### Discussion

These results demonstrate that, in the rat, ligation of the bile duct leads rapidly to a large and selective rise in the concentration of IgA in serum. This additional IgA is predominantly, if not entirely, of the secretory type. FSC also appears in serum after ligation. At 24 h after obstruction, these changes are completely reversible within a few days by reopening the duct, whereby FSC first disappears from serum, followed by the slower decline of SIgA in the serum.

An explanation for these findings may reside in our observation (7) that rat bile is a rich source of SIgA and FSC. These proteins could simply regurgitate in serum after ligation of the bile duct. The amounts of SIgA and FSC found in serum at 24 h after ligation are compatible with this hypothesis. Furthermore, we have found in rats (unpublished observations) and mice (13), a very rapid initial serum clearance of intravenously injected monoclonal IgA; this initial clearance was so rapid that it seemed improbable that extravascular equilibration and catabolism could be the sole factors involved. Some IgA may be

secreted into exocrine secretions. In mice, the injected IgA was easily detected in several exocrine secretions, with a surprisingly high level in bile, where it was entirely bound to SC (14). In rats, liver perfusion experiments showed an active transfer of rat monoclonal IgA from the perfusion medium into bile, where it was also bound to SC.<sup>1</sup> These data imply that in rats and mice, the liver actively removes IgA from serum and transfers it into bile in the form of SIgA.

Why does the liver do this? IgA antibodies in serum (15), mainly IgA polymers (16), have been claimed to have potentially adverse effects against defense mechanisms, and the liver could prevent their accumulation in serum. In addition, it was shown that a significant contribution to rat serum IgA was coming from the intestinal mucosa plasma cells via the mesenteric and thoracic duct lymph (8). It is attractive to think that some IgA molecules which were synthesized in the intestine mucosa plasma cells, but which did not directly find their way to the intestinal secretions, could still become SIgA in the duodenum via the lymph, general circulation, liver, and bile. This could represent a reinforcement mechanism of the local intestinal immunity. It is desirable to know whether this additional SIgA is of minor or major importance.

It remains to be determined if all the IgA in rat bile (and in serum after bile duct obstruction) is of circulatory origin, or if a substantial fraction is synthesized locally as is reported to be the case in humans and dogs (17-20). Also, it should be examined whether the mechanism of transfer of IgA in bile is the same as those in intestinal (21-23) and mammary (24) secretions.

The relevance to the human SIgA system of these studies on rats may be the high IgA levels in human serum detected in all patients with liver disease, and in particular in those with primary biliary cirrhosis and obstructive jaundice (25).

### Summary

In the rat, ligation of the bile duct induces a rapid and progressive elevation of the IgA levels in serum. The increase is about 4-fold at 1 h, 15-fold at 1 day, and 30-fold at 1 wk after ligation. The additional IgA is of the secretory type. Free secretory component also appears in serum after bile duct obstruction; it does not continue to increase and occasionally disappears from serum after prolonged ligation. The increase in serum IgA levels is selective. These changes are totally reversible if the bile duct is reopened at 1 day after ligation. These findings confirm the role of the rat liver in the transfer of circulating IgA into the bile.

The technical assistance of A. De Ryck-Langendries, R. Meykens, and J. Naze-Demets was highly appreciated, as was the competent editorial work of V. De Chestret.

*Received for publication 13 October 1977.*

### References

1. Tomasi, T. B., and J. Bienenstock. 1968. Secretory immunoglobulins. *Adv. Immunol.* 9:1.
2. Vaerman, J. P. 1973. Comparative immunochemistry of IgA. *Res. Immunochem. Immunobiol.* 3:91.
3. Waldman, R. H., J. P. Mach, M. M. Stella, and D. Rowe. 1970. Secretory IgA in human serum. *J. Immunol.* 105:43.

4. Mach, J. B., and J. J. Pahud. 1971. Secretory IgA, a major immunoglobulin in most bovine external secretions. *J. Immunol.* 106:552.
5. Vaerman, J. P., M. C. Naccache-Corbic, and J. F. Heremans. 1975. Secretory component of the guinea-pig. *Immunology.* 29:933.
6. Bazin, H., A. Beckers, J. P. Vaerman, and J. F. Heremans. 1974. Allotypes of rat immunoglobulins. I. An allotype of the  $\alpha$ -chain locus. *J. Immunol.* 112:1035.
7. Lemaître-Coelho, I., G. D. F. Jackson, and J. P. Vaerman. 1977. Rat bile as a convenient source of secretory IgA and free secretory component. *Eur. J. Immunol.* 7:588.
8. Vaerman, J. P., C. André, H. Bazin, and J. F. Heremans. 1973. Mesenteric lymph as a major source of serum IgA in guinea pigs and rats. *Eur. J. Immunol.* 3:580.
9. Vaerman, J. P., J. F. Heremans, H. Bazin, and A. Beckers. 1975. Identification and some properties of rat secretory component. *J. Immunol.* 114:265.
10. Lambert, R. 1965. Surgery of the Digestive System in the Rat. Charles C Thomas, Publisher, Springfield, Ill. 113.
11. Mancini, G., A. O. Carbonara, and J. F. Heremans. 1965. Immunochemical quantitation of antigens by single radial immunodiffusion. *Immunochemistry.* 2:235.
12. Johansson, B. G. 1972. Agarose gel electrophoresis. *Scand. J. Clin. Lab. Invest. Suppl.* 124:7.
13. Jackson, G. D. F., I. Lemaître-Coelho, and J. P. Vaerman. 1977. The clearance of MOPC-315 tumour immunoglobulin A from the serum of BALB/c mice. *Biochem. Soc. Trans.* 5:1576.
14. Jackson, G. D. F., I. Lemaître-Coelho, and J. P. Vaerman. 1977. Transfer of MOPC-315 IgA to secretions in MOPC-315 tumour-bearing and normal BALB/c mice. *Protides Biol. Fluids. Proc. Collog. Bruges.* 25:919.
15. Griffis, J. M., and M. A. Berham. 1976. Serum IgA and susceptibility to meningococcal disease. *Clin. Res.* 24:344a. (Abstr.).
16. Van Epps, D. E., and R. C. Williams, Jr. 1976. Suppression of leukocyte chemotaxis by human IgA myeloma components. *J. Exp. Med.* 144:1227.
17. Dive, C. 1970. Les protéines de la bile. Leur composition et leur origine. Thesis, Editions Arscia, Bruxelles, and S. A. Maloine, Paris.
18. Hadziyannis, S., T. Feizi, P. J. Scheuer, and S. Sherlock. 1969. Immunoglobulin-containing cells in the liver. *Clin. Exp. Immunol.* 5:499.
19. Dive, C., and J. F. Heremans. 1974. Nature and origin of the proteins of bile. I. Serum and bile proteins in man. *Eur. J. Clin. Invest.* 4:235.
20. Dive, C., R. A. Nadalini, J. P. Vaerman, and J. F. Heremans. 1974. Origin and nature of the proteins of bile. II. A comparative analysis of serum, hepatic lymph and bile proteins in the dog. *Eur. J. Clin. Invest.* 4:241.
21. Poger, M. E., and M. E. Lamm. 1974. Localization of free and bound secretory component in human intestinal epithelial cells. A model for the assembly of secretory IgA. *J. Exp. Med.* 139:629.
22. Brandtzaeg, P., and K. Baklien. 1977. Intestinal secretion of IgA and IgM: a hypothetical model. *Ciba Found. Symp.* 46:77.
23. Brown, W. R., Y. Isobe, and P. Nakane. 1975. Ultrastructural localization of IgA and secretory component (SC) in human intestinal mucosa by immunoperoxidase techniques. *Gastroenterology.* 68:869.
24. Kraehenbuhl, J. P., L. Racine, and R. E. Galaray. 1975. Localization of secretory IgA, secretory component and  $\alpha$  heavy chain in the mammary gland of lactating rabbits by immunoelectron microscopy. *Ann. N. Y. Acad. Sci.* 254:190.
25. Thompson, R. A., R. Carter, R. P. Stokes, A. M. Geddes, and J. Goodall. 1973. Serum immunoglobulins, complement component levels and autoantibodies in liver disease. *Clin. Exp. Immunol.* 14:335.