The multiple aetiology of viral hepatitis

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Summary
Infectious hepatitis is epidemiologically and immunologically distinct from serum hepatitis. The Australia antigen is related more specifically to serum hepatitis.

The possible role of coronavirus—and paramyxovirus-like particles in the aetiology of some infections of the liver in man and in marmosets inoculated with human infectious hepatitis material is discussed and the difficulties in the interpretation of the currently available data are emphasized.

The recent studies in Melbourne of a faecal antigen found in some patients with infectious hepatitis and the discovery of an antiserum in Milan which reacted with an antigen associated with epidemic hepatitis are discussed. Mention is made of the recent isolation in Detroit-6 cells of virus-like particles from patients with infectious hepatitis.

It is concluded that viral hepatitis is an infection of multiple aetiology and that the successful cultivation in vitro of the agent or agents of hepatitis remains the outstanding and most urgent problem.

Definition
The usual definition of viral hepatitis is acute inflammation of the liver caused by two infectious agents, presumably viruses, named virus A, the aetiological agent of infectious hepatitis or epidemic hepatitis and virus B, which is the cause of serum hepatitis or homologous serum jaundice. The definition excludes by common usage acute inflammation of the liver which may be induced by well recognized viruses such as yellow fever, adenoviruses, cytomegalovirus, coxsackie viruses, herpes simplex virus and others (reviewed by Zuckerman, 1970a). It is virtually impossible to distinguish between the two clinically and pathologically similar forms of viral hepatitis. Factors which make such a differentiation even more difficult are that serum hepatitis may be transmitted by the oral route (Krugman, Giles & Hammond, 1967) and conversely infectious hepatitis may be transmitted parenterally. However, characterization of the infectious type of hepatitis is possible on meticulous epidemiological grounds such as those outlined by Mosley (1970) namely an average incubation period to the onset of symptoms of approximately 30 days, clear evidence of spread by person-to-person contact or a common source of infection and protection of individuals in the same epidemiological setting by human immunoglobulin in a small dose. Indeed, reference to the nomenclature of infective hepatitis (Table 1), which is bedevilled by a multitude of synonymous terms, reveals a consistent feature throughout: the predominant association of infectious hepatitis with an epidemic setting and the more sporadic nature of serum hepatitis and its association with a parenteral mode of transmission.

Furthermore, volunteer experiments have clearly

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<th>Table 1. The terminology of viral hepatitis</th>
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<td><strong>Infectious hepatitis</strong></td>
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<tr>
<td>Icterus epidemicus-epidemic jaundice</td>
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<td>Catarrhal jaundice</td>
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<td>Epidemic catarrhal jaundice</td>
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<td>Jaunisse des campes</td>
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<td>Soldatengelbsucht</td>
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<td>Infectious jaundice</td>
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<td>Epidemic hepatitis</td>
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<td>Infective hepatitis (virus A)</td>
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<td>Acute viral hepatitis</td>
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<td>Botkin's disease</td>
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<td>Short incubation hepatitis (MS-1 infection)</td>
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<td>Infectious (MS-1) hepatitis</td>
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Aetiology of viral hepatitis

established that these two types of acute hepatitis are caused by aetologically distinct agents, infectious hepatitis which has a short-incubation period and serum hepatitis with long-incubation.

The Australia antigen
The discovery of the remarkable association between viral hepatitis and a serum antigen named the Australia antigen (Blumberg et al., 1967) has provided specific serological tests for a proportion of cases of hepatitis. While many conflicting results have been reported on the immunological specificity of the Australia antigen it now appears that this antigen is related more specifically to serum hepatitis or type B viral hepatitis and not epidemic hepatitis (Zuckerman, 1970b, c), although some doubts may be expressed about the viral nature of this antigen (Zuckerman, 1970d; Zuckerman, Taylor & Bird, 1970).

Coronavirus and paramyxovirus-like particles in hepatitis
Anticomplementary activity was observed by Patricia E. Taylor & A. J. Zuckerman in the course of testing sera by complement-fixation for the Australia antigen. Electron microscopic examination of sera from one such patient with chronic active hepatitis revealed the presence of virus particles displaying the typical morphological features of a member of the coronavirus group (Zuckerman, Taylor & Almeida, 1970). All the virus particles were in association with antibody and the complement-fixing antibody titre to prototype mouse hepatitis virus 3, a known coronavirus, was 1 : 640. This observation was of interest in view of the analogy with the previous findings of circulating antigen–antibody complexes in some patients with serum hepatitis (Taylor, Zuckerman & Brighton, 1969; Almeida & Waterson, 1969). The additional finding of high titre antibody crossing serologically with mouse hepatitis virus also raised the possibility that these particles may be a human counterpart to the mouse hepatitis virus.

Deinhardt and his associates (personal communication, 1970) and Holmes et al. (1970) independently observed paramyxovirus-like particles in the acute phase of two patients with infectious hepatitis and in acute phase sera of marmosets with experimentally induced hepatitis. Normal serum specimens and acute phase sera of patients with viral hepatitis and the sera of marmosets were examined in two ways: by caesium chloride density gradient centrifugation and electron microscopy and by testing for infectivity in marmosets. Paramyxovirus-like particles were found in acute phase sera of inoculated marmosets and in acute phase serum specimens of two human patients, one of which also induced hepatitis in marmosets. The fractions with a density of about 1·21 g/cm³ were infectious for marmosets. Virus-like particles were not found in non-infectious fractions of different densities. An Australia antigen-positive serum and its 1·20 × 1·25 g/cm³ and 1·30 × 1·32 g/cm³ caesium chloride density gradient fractions were not infectious for marmosets. Further studies are currently in progress to confirm and extend these observations and no firm conclusions should, at this time, be drawn from these findings.

Apodaca et al. (1970) also described coronavirus- and paramyxovirus-like particles in marmosets inoculated with human infectious hepatitis material. Five sera were examined under code by Zuckerman, Taylor & Bird (unpublished observations) and virus-like particles (Fig. 1) were found in the three acute phase sera collected from the inoculated marmosets but not in the serum of the control animals. Hunter et al. (1970) also found paramyxovirus-like particles in a number of patients with chronic liver disease. The significance of coronavirus-like particles together with the structures usually associated with the Australia antigen in a number of serum specimens (Fig. 2) obtained from different patients with hepatitis is impossible to interpret at this stage (Zuckerman, 1970c; Wright, 1970).

More recently Sirtori (1970a, b) examined by electron microscopy percutaneous liver biopsies obtained from three children with infectious hepatitis who were treated with azathioprine. Many virus-like particles measuring 80–160 nm in diameter...
and displaying the morphology of the corona-
paramyxovirus group were found in the cytoplasm
of the hepatocytes and Kupffer cells. Some of these
particles were shown to be budding from the cell
membrane. It is also of interest that serum specimens
from these three children reacted in the two dimen-
sional micro-Ouchterlony technique to give precipi-
titin lines with an antiserum possessing specificities
for both serum hepatitis (associated with the Aus-
tralia antigen) and epidemic hepatitis (Del Prete et al.,
1970).

However, all these observations are preliminary
in nature and they must be interpreted with con-
siderable caution since they do not, of course, prove
that these virus-like particles are specifically associ-
ated with or are causally related to infectious hepa-
titis. These virus-like structures may indeed play
only a secondary role, if any, in some forms of
human liver disease. This view is shared by Zuck-
eman and his associates and by Deinhardt and his
group, and both stress that the data available so far
merely indicate possible lines for further investiga-
tion.

A faecal antigen in infectious hepatitis

Ferris et al. (1970) described a faecal antigen in
some patients with infectious hepatitis. Bacteriolo-
gically sterile supernatants were obtained by high
speed centrifugation of a 20% suspension of faeces
collected from six patients with viral hepatitis in
whom the Australia antigen was not detected in
the serum. The faecal extracts were tested by gel
diffusion against sera from thirty-seven multi-
transfused haemophiliacs. Two such sera gave
precipitin lines with four of the six faecal extracts,
but no reaction was obtained with sera from these
patients nor from six patients with other diseases.
Two rabbits were immunized with positive faecal
extracts which has been purified by fractionation on
sucrose gradients. The rabbit antisera were absorbed
with normal human serum and twice with faecal
extracts from non-hepatitis patients. Single preci-
titin lines were observed when faecal extracts from
ninety out of 220 (40.9%) patients with viral hep-
titis and five out of 158 (3.1%) without hepatitis
were tested against one of the rabbit antisera.
Positively reacting faecal extracts did not react with
human or animal anti-Australia antigen sera.
Cross and his associates (personal communication,
1970) extended their preliminary observations, and
immune electron microscopy indicated the presence
of two virus-like particles in the faecal antigen.
One particle measures 15–25 nm in diameter and
closely resembles the small particle associated
with the Australia antigen (Almeida et al., 1969) and
the other is a 40–45 nm particle also found in many
Australia antigen positive sera (Fig. 3) (Dani,
Tubular forms were not found in extracts containing
the faecal antigen. Cross-serological tests in gel
and immune electron microscopy suggest that there
are two antigenically distinct types of the small
particles, one associated with the Australia antigen
and the other associated with the faecal antigen,
whereas the larger and somewhat more pleomorphi-
particles appear to possess a common group component as well as a type-specific component. Further studies of these important observations are in progress.

A serum antigen in epidemic hepatitis

Recently Del Prete et al. (1970) found a human antiserum in Milan which reacted in the immunodiffusion test with sera from patients with long-incubation hepatitis and also with short-incubation hepatitis. This new antiserum detected by gel diffusion a serum antigen associated with classical epidemic hepatitis. A high proportion of sera from three epidemics of short-incubation hepatitis, which were consistently negative with anti-Australia antigen sera tested both by the immunodiffusion technique and by complement-fixation, reacted with the Milan antiserum. Thus a precipitin line was demonstrated in 65% of 127 patients involved in three separate epidemics of infectious hepatitis and the percentage of positive reactions increased to 90% in sera obtained during the first week of symptoms. The antigen was cleared from the serum with clinical improvement. This new epidemic hepatitis-associated antigen was found to be remarkably labile, which is a somewhat unexpected finding in view of the known physical stability of the hepatitis agents. It is appreciated, of course, that this antigen might be antigenically distinct from the hepatitis virus in the same way as the H antigen of poliovirus is antigenically distinct from the antigen on the native virus.

These observations are of great interest since they may ultimately provide specific serological methods for distinguishing between infectious hepatitis and serum hepatitis.

Virus-like particles in infectious hepatitis

Finally, reference is made to the work of W. A. Rightsel and his associates with the haemoviruses and in particular with the AR-17 agent using the Detroit-6 cell line. This subject was recently reviewed in some detail (Zuckerman, 1970e). Attempts to culture the AR-17 agent in the semi-continuous human embryo liver cell line resulted in a cytopathic effect in these cells which could not be transferred beyond the first passage (Zuckerman et al., 1970). There was no evidence of chromosomal damage in the inoculated cells. Detroit-6 cells inoculated with the AR-17 agent by W. A. Rightsel in Memphis were examined by negative staining and electron microscopy in London in 1969. Pleomorphic particles measuring 18–23 nm in diameter and arranged in characteristic chain-formation and in clumps were found in the inoculated cultures (Fig. 4). It was impossible to interpret the significance of these observations, if any, especially in the absence of other supporting evidence. More recently, Melnick et al. (1970) isolated a virus from the acute phase plasma of a volunteer who developed hepatitis 4 weeks after inoculation with infectious hepatitis serum. This agent produced cytopathic changes in a cloned line of Detroit-6 cells. Particles measuring approximately 18 nm were found by electron microscopy in material harvested from the infected cells cultures. Similar viruses were also isolated in Detroit-6 cells from the sera of six other patients with acute infectious hepatitis. Further work is in progress to elucidate the significance of these findings. It is becoming apparent, however, that viral hepatitis should indeed be regarded as an infection of multiple aetiology and the problem could only be resolved by the successful in vitro cultivation of the newly described antigens and agents of hepatitis.

Acknowledgments

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References

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