Alpha\textsubscript{1}-antitrypsin, a reliable endogenous marker for intestinal protein loss and its application in patients with Crohn’s disease

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SUMMARY Intestinal protein loss is generally determined by radio-labelled macromolecules. Alpha\textsubscript{1}-antitrypsin has been proposed as an endogenous marker for protein losing enteropathy, but different opinions exist about its reliability. In 25 patients with Crohn’s disease faecal protein loss was studied with intestinal alpha\textsubscript{1}-antitrypsin (\(\alpha_1\)AT) clearance. Simultaneously, in 10 patients \(\alpha_1\)AT clearance was compared with faecal \(^{51}\)Cr clearance after intravenous \(^{51}\)Cr-albumin injection. There was a linear relation \((p<0.05)\) between \(\alpha_1\)AT clearance and \(^{51}\)Cr clearance in these cases. In all patients \(\alpha_1\)AT clearance was raised above control values. \(\alpha_1\)AT clearance, however, did not correlate with the activity index of Crohn’s disease.\(^1\) This index does not contain direct criteria of intestinal inflammation, does not take into account localisation or extent of inflammation, and includes complications such as extraintestinal manifestations, fistuli, stenoses not necessarily related to actual mucosal involvement. It is concluded that \(\alpha_1\)AT is a reliable marker for intestinal protein loss and that the intestinal changes of Crohn’s disease generally lead to an increased protein exudation into the gut.

Gastrointestinal loss of plasma proteins can be detected by a variety of labelled macromolecules: \(^{59}\)Fe-labelled dextran\(^2\) and \(^{131}\)I-PVP\(^3\) are not split by digestive enzymes; the radioactive isotopes \(^{51}\)Cr-albumin,\(^4\) \(^{67}\)Cu-ceruloplasmin\(^5\) or \(^{95}\)Nb-albumin\(^6\) are poorly absorbed by the alimentary tract. These methods are expensive and the patients are exposed to radioactivity and therefore cannot be used routinely as screening-tests or to monitor the course of illness. Crossley and Elliot\(^7\) showed that \(\alpha_1\)AT, a protease inhibitor synthesized by the liver and present in serum at a concentration of 2–5 g/l, is not degraded by digestive enzymes nor reabsorbed by the intestine. It has been shown to be a reliable endogenous marker of intestinal protein loss by Bernier and colleagues.\(^8\) These authors reported that both faecal \(\alpha_1\)AT concentration and \(\alpha_1\)AT clearance were significantly higher in patients with suspected exudative enteropathy than in controls. Their results were not confirmed by Haaney et al.,\(^9\) who compared \(\alpha_1\)AT concentration and \(\alpha_1\)AT clearance with the conventional \(^{51}\)Cr-albumin method. According to Keaney and Kelleher\(^10\) the contradictory results could be caused by a difference in methods and by comparison of different parameters.

We examined the validity of \(\alpha_1\)AT as a reliable indicator of intestinal protein loss in patients with Crohn’s disease, comparing \(\alpha_1\)AT clearance with the clearance of \(^{51}\)Cr-albumin and studied problems of methodology.

Finally, we tried to correlate intestinal \(\alpha_1\)AT clearance with site, extent, and activity of intestinal inflammation or resection in Crohn’s disease.

Methods

Patients

Alpha\textsubscript{1}-antitrypsin clearance was determined in 10 healthy controls and in 25 patients with Crohn’s disease (mean age 31.6±2.5, range 18–63 years; 17 women, eight men). The site and extent of inflammation was documented radiologically and/or by endoscopy and histology (Table). Ten patients had undergone intestinal resection, five of them suffered from anastomosal relapse. Twelve patients had complications: intestinal stenosis occurred in six
patients (one of them also having anal fistula), extraintestinal manifestations (arthritis and erythema nodosum) in two patients (one also having anal fistula), perianal complications only in two patients and internal fistulae occurred in two patients.

In all patients the CDAI1 was established. In the Table data on ESR, serum albumin concentrations, haematocrit and therapy are also given.

In 10 patients α1AT clearance was compared with faecal excretion of intravenously injected 51Cr-albumin and with the intestinal 51Cr clearance.

**DETERMINATION OF ALPHA1-ANTITRYPSIN**

Alpha1-antitrypsin of serum and faeces was determined by radial immunodiffusion. The diameter of the precipitation ring of the plates containing a monospecific antigen against α1AT (Behringwerke) was measured after 72 hours and compared with a reference curve established from the diameters of rings of a standard solution. Faeces and sera were kept at −20°C until used. The volume of the three day stool samples was calculated by weight and specific gravity. Specific gravity was determined by weighing a volume of 5 ml of the homogenised stool. An aliquot of 2 g of the homogenised stool was diluted 1:4 with normal saline or for comparison with aqua dest, and again homogenised for 10–60 minutes. After centrifugation at 1500–3000 g for 10–30 minutes 5 μl of the supernatant was applied to the plates. The sera obtained at the beginning of stool sampling were diluted 1:5 in normal saline and 5 μl of the samples were applied to the plates. In five samples the
determinations were repeated after storage of faeces and sera for eight months at −20°C. Faecal α1AT loss was calculated from faecal α1AT concentration and stool volume. α1AT clearance was calculated by the formula

\[
\text{\( \alpha_1\text{AT clearance} = \frac{\text{faecal volume} \times \alpha_1\text{AT faecal concentration}}{\alpha_1\text{AT serum concentration}} \)}
\]

\[51\text{Cr-albumin method}\]

The radioactivity of the three day stool samples (Behringwerke) was measured, after intravenous injection of 10 \( \mu \text{Ci} \) \( 51\text{Cr} \)-albumin, with a gamma counter. The \( 51\text{Cr} \)-serum concentration was calculated from the administered \( 51\text{Cr} \)-dose and from the total serum volume calculated by conventional formulas. The formula for computing the \( 51\text{Cr} \) clearance corresponded to that for \( \alpha_1\text{AT} \).

**Results**

There was a good correlation between \( \alpha_1\text{AT} \) clearance and \( 51\text{Cr} \) excretion (\( r=0.84, \alpha=5\% \)) or \( 51\text{Cr} \) clearance (\( r=0.87, \alpha=5\% \)). The relation between \( \alpha_1\text{AT} \) and \( 51\text{Cr} \) clearance as expressed by a linear equation was \( y=0.73+4.42 \) (Fig. 1). The different methods of treating the faeces with normal saline or aqua dest, the duration of homogenisation, and the rpm of centrifugation, had no influence on the results. After storage of the stool and the serum at −20°C for eight months the recovery rate of \( \alpha_1\text{AT} \) was more than 90%.

In our experiments the faecal loss of \( \alpha_1\text{AT} \) in patients with Crohn’s disease (average 308 mg/d, range 22–785 mg/d) was higher than in controls (average 54 mg/d, range 0–136 mg/d) (Fig. 2). When the clearance of \( \alpha_1\text{AT} \) was calculated there was a better separation (Fig. 2) of patients with Crohn’s disease (average 93 ml/d, range 19–367 ml/d) from controls (5 ml/d on an average, range 0–22 ml/d) and with only one exception \( \alpha_1\text{AT} \) clearance was raised above control values in all patients. As shown in Fig. 3 there was no difference between patients with involvement of the small intestine only, and the colon only. The clearance of \( \alpha_1\text{AT} \) in patients with skip lesions of the large bowel was similar to those with total colonic inflammation and the same findings applied to the inflammation of the ileum. Three patients with inflammation of both colon and ileum had higher values than those who had only the ileum or the colon involved. On the other hand three patients with relapse of Crohn’s disease over a small segment adjacent to the anastomosis had higher values than others with total colonic and/or ileal involvement. Even after curative resection

![Fig. 1 Relation between \( \alpha_1\text{AT} \) clearance and \( 51\text{Cr} \)-albumin clearance.](image)

![Fig. 2 Faecal \( \alpha_1\text{AT} \) loss and intestinal \( \alpha_1\text{AT} \) clearance in patients with Crohn’s disease and controls.](image)
Alpha_1-antitrypsin, a marker for intestinal protein loss in Crohn's disease

faecal alpha_1-AT was raised. The increase of faecal alpha_1-AT in the resected patients was about twice above control values. There was no correlation between activity index and alpha_1-AT clearance (Fig. 4). Patients with inflammation in remission (activity index <150) had values of alpha_1-AT clearance similar to patients with a CDAI higher than 400.

In patients with complications such as fibrous strictures, anorectal fistulation, or extraintestinal manifestations, the mean CDAI (206±43) was significantly higher (p<0.02) than in patients without complications (99±19) (Fig. 5).

The mean alpha_1-AT clearance in patients without complications (104.9±26.5 ml/d) was raised above
the values of patients with complications (73.1±22.8 ml/d) (Fig. 6).

**Discussion**

Similar to the results of Florent and coworkers\(^\text{12}\) we found a linear relationship of the intestinal protein loss measured by \(^{51}\text{Cr}\) or by \(\alpha_1\text{AT}\) clearance. The slope of the curve comparing \(\alpha_1\text{AT}\) and \(^{51}\text{Cr}\)-albumin clearance (Fig. 1) should be unity provided both proteins follow the same mechanism of transmucosal exudation, whereas a value of 0.73 was calculated from our results. There is some destruction of \(\alpha_1\text{AT}\) in gastric juice of pH below 3,\(^\text{13}\) but from the results of Crossley and Elliot\(^\text{7}\) it is unlikely that \(\alpha_1\text{AT}\) is degraded in the small or large bowel to any significant degree nor is \(^{51}\text{Cr}\) absorbed to any appreciable extent.\(^\text{14}\) Moreover, the molecular weights of \(\alpha_1\text{AT}\)\(^\text{15}\) and albumin are comparable and no significant difference exists in exudative enteropathy in the loss of small or large proteins. Höfer et al\(^\text{16}\) found that chromated albumin is present in a monomer fraction and in an aggregated \(^{51}\text{Cr}\)-albumin fraction. The metabolic behaviour of the aggregate and monomer fraction is different. The aggregate fraction is stored in the liver in a greater amount than the monomer fraction followed by a smaller intestinal exudation, which could possibly explain the difference between \(\alpha_1\text{AT}\) and \(^{51}\text{Cr}\) clearance.

Differences in preparing stool such as dilution, homogenisation, or centrifugation, had no influence on the determination of \(\alpha_1\text{AT}\). Therefore the contradictory results of Bernier et al\(^\text{18}\) and Haaney et al\(^\text{19}\) cannot be explained in that way.

Our results confirm those of Bernier et al\(^\text{18}\) in that no overlap of \(\alpha_1\text{AT}\) clearance was seen in patients and controls, and all patients had raised \(\alpha_1\text{AT}\) clearance levels (Fig. 2). If all patients with Crohn's disease lost serum proteins into the intestinal lumen one should expect a quantitative correlation of intestinal protein loss or serum albumin concentrations and extent and/or severity of disease.\(^\text{13,17}\) This was not so in our cases. Even patients with apparent curative resection had raised values while others with a high activity index or those with extensive involvement had relatively minor protein losses (Figs. 3, 4). An explanation for this paradox may be that normal macroscopic appearance of the mucosa does not exclude histological involvement with changes characteristic of Crohn's disease.\(^\text{3,18,19}\) Lymph drainage may be impaired and protein exudation increased if the mesenteric and lymph nodes are involved, features which cannot be diagnosed by radiology. On the other hand quiescent disease may still show impressive radiological changes.

Florent et al\(^\text{13}\) found an exceptionally good correlation between the intestinal \(\alpha_1\text{AT}\) clearance and the clinical activity assessed by the CDAI. From our results it is not possible to ascertain any coherence between CDAI and intestinal protein loss. The important objection to the CDAI is, that it is largely determined by subjective variables that may not generally be reliable indicators of the intestinal inflammatory activity but often result from complications or residual effects of the disease. It is obvious that considerable subjective complaints like fibrous strictures, anorectal fistulation, extra-intestinal manifestations, or conglomerate tumour may not necessarily be related to the severity of intestinal inflammation. Accordingly, in patients with complications the mean CDAI was higher than in patients without complications (Fig. 5). In contrast the mean \(\alpha_1\text{AT}\) clearance in patients without complications was raised above the values of patients with complications (Fig. 6). From this comparison it is obvious that in patients suffering from complications the CDAI reflects a much higher clinical activity as it is evident from the intestinal protein loss indicating severity of the local intestinal inflammation.\(^\text{14}\)

Discrepancies between the quantity of intestinal protein loss and the activity of Crohn's disease estimated by the Best index may be explained by the absence of mucosal parameters as determining factors for this index. The same reason may apply for the six of 14 patients of Florent et al\(^\text{13}\) who had raised \(\alpha_1\text{AT}\) clearances in spite of a normal Best index and developed a relapse on follow up.

Selection of patients may be another cause explaining differences of the studies. Twenty-eight out of the 30 patients of Florent et al\(^\text{14}\) with Crohn's disease had marked hypoalbuminemia (mean serum albumin concentration 2.73±0.53 g%). Only nine out of 26 of our patients had albumin concentrations below 3.6 g% (mean value 3.80±0.57 g%).\(^\text{17,20}\) Furthermore, these authors studied patients without previous intestinal surgery whereas 10 of our patients had undergone intestinal resection and complications were not documented.

Protein loss via the intestinal wall seems to be one of the most accurate parameters to measure the inflammatory activity in the intestine.\(^\text{14}\) So the determination of \(\alpha_1\text{AT}\) by radioimmunodiffusion may be a convenient and reproducible objective method to assess severity of intestinal inflammation.

Further investigations will show if the \(\alpha_1\text{AT}\) clearance is to be of use following the course of illness or the efficacy of therapy in patients with Crohn's disease.
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