Anatomical, Physicochemical, Biochemical and Bio-Electronic Aspects of Human Fascia and Fat – An Attempt and Evidence for Obesity Control

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Abstract: Nanomaterials and nanotechnology has revolutionized the quick and sensitive mode of diagnosis and also in therapy of various human diseases. Our group intend to explore the reason for obesity in children, a growing problem in the Indian population. Prevention of obesity at childhood is an obvious alternative measure to the possible precipitation of disabilities including, arthritis, diabetes, cardiological and lever related diseases at a later age. In this direction, a comparison of the structure of human fasciae at upper and lower abdomen was carried out to find the anatomical variation and hanging of lower abdomen especially in women. The fat obtained from twenty cadaver were subjected to various physicochemical, biochemical parameters and it was used as a thin film material. The microscopic and radiological investigation of fascia and fat was also analyzed for the cause of deposition of fat.

The result indicated the superiority of the microscopic methods compared to the radiological procedure in children. The elastic parameters are such that the lower abdomen fasciae has better tensile strength. The physicochemical parameters evaluated indicated the more fluidic behavior of lower abdomen fat leading to the observed hanging of lower abdomen. Biochemical parameter indicated the difference in the fatty acid content in the fat from two sections. The thin film parameter indicated that fat could be a good candidate as a dielectrics material and could be used as a probable biosensor. It is proposed that, apart from the known causes, it is the lack of signal communication between the selected organs is also responsible for fat metabolism and thus signal processing is yet another factor contribute for the fat deposition at the early age of childhood. We propose to use human fat a biomaterial in thin film technology as a biosensor for the early manifestation of fat deposition in children and propose remedial measure to control childhood obesity.

Introduction:

The deposition of subcutaneous fat in lower abdomen does not get absorbed easily by dieting and exercise, as compared to the upper abdomen (1-8). The anatomical and physicochemical properties of subcutaneous fat and superficial fascia may be responsible for this difference in the properties. However, the studies on anatomical and physicochemical properties were scanty in the available literature. Superficial fascia of the abdomen, being a supportive structure, its anatomy, histology and biochemical composition may play a vital role in central abdominal obesity as well as in surgical treatment of obesity. Superficial fascia of the abdomen lies between the skin and muscles of the anterior abdominal wall. There has been considerable controversy with respect to the number of layers and the level of subdivisions of the superficial fascia of the abdomen. The layers of the superficial fascia and its level of division can vary considerably as stated by different authors (10, 11).

Obesity is a universal problem due to the deposition of excess acyltriglycerides in the subcutaneous internal adipose tissues. One of the causative factors for diabetes, hypertension arthritis and cardiovascular, neurological, psychological disorders is obesity. In this direction, the mechanism of esterification and de-esterification process of the acyltriglycerols which is mainly controlled by various bio-chemical path ways is mainly influenced by the insulin metabolism through other enzymes and hormones. Whether non surgical procedure could benefit the patient? An alternative to the liposuction procedure or diet control could be used to tackle the pathways of fat metabolism and to accelerate the de-esterification of acyltriglycerides into corresponding fatty acids. This could be understood initially by studying the in-vitro physicochemical, biochemical, thermal and certain electrical properties of the fat along with the adipose tissues isolate from liposuction. The electrical, magnetic, optical and thermal analysis is in progress and the preliminary data will be presented. This may help in the development of a suitable obesity sensitive biosensor (9).

Experimental:

Fat isolated from twelve obese patients whose BMI is much above the normal adults who have volunteered for the liposuction surgery (ethical clearance is obtained) is used for the physico-chemical analysis. The sample along with the blood was repeatedly washed with saline (8-10 times) and the fat obtained in dried using desiccators, stored and used for the experiment.
The superficial fascia of selected number of cadavers (obtained from the mortuary, KMC, Manipal after obtaining the clearance from the ethical committee) were also examined for their anatomical variation in the anatomical structure of the upper and lower abdomen. The study was done on 40 fresh adult cadavers (33 males and 7 females) and 12 formalin fixed adult cadavers (6 males and 6 females) collected from the Department of Forensic Medicine and Anatomy and four dead fetuses (2 males & 2 females) with the gestational age 16 weeks collected from the Department of Obstetrics & Gynaecology, K.M.C. Manipal during 2010 to 2013. The solution (1%) of fat in organic (MeOH:CHCl3) and aqueous medium (1% Triton in saline solution) were prepared and used for analysis (9,11). Samples were analysed for Physico chemical including surface tension, viscosity, thermal, biochemical properties. A known quantity of the sample is dissolved in Toluene and it is used to prepare the film using spin coating technique. The obtained films are used in the evaluation of electrical conductivity using Keithley Instruments curve tracer. The microscopic and radiological study of the fetus fascia upper and lower abdomen were conducted at the dept. of pathology and Radiology department of KMC by the standard method. Thus the fat from live patients were subjected to Physicochemical study, anatomical study of cadaver and radiological study on fetus was conducted which covers the wide range of patients. This may help in generalizing the hypothesis. Due to lack of availability of fetus which was a difficult task the number of fetus were less and could not arrive at any statistical analysis.

Results and discussion:
The physicochemical properties were presented earlier hence not included in this paper (9, 11). The thermal properties studied using DSC analysis showed that the fat does not only contain the triglycerides but also many other constituents and the water content exists both inside and outside the tissues as seen in two endotherms at 80°C and 120 °C (Fig 1, table 1).

![Figure 1.DTA and DSC thermo-gram of 8 samples](numbers indicate the patient code)

The presence of water is also a factor for the inflammation of the adipose tissue leading to obesity as evidenced by the earlier workers (10). This was further confirmed by exercise and starving theory in obesity patients.

<table>
<thead>
<tr>
<th>Table 1. Thermal data: The thermal properties of fat containing the tissues were studied (table 1).</th>
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<tr>
<td>The biochemical evaluation leads to the conclusion that higher amount of fat deposition containing large amount of fatty acids containing different unsaturated fatty acids, having large chain incorporated in (Table 2).</td>
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![Table 1. Thermal data](numbers indicate the patient code)

<table>
<thead>
<tr>
<th>Table 2: Biochemical Analysis indicating the fat content, triglyceride content (T.G), saponification values (S.V) and iodine values (I.V.) of fat samples obtained from various patients.</th>
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<td>The thin film fat coated on a glass substrate subjected to the electrical properties revealed the linearity of the I-V curve obeying the Ohm’s Law (Fig. 2).</td>
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![Table 2: Biochemical Analysis indicating the fat content, triglyceride content (T.G), saponification values (S.V) and iodine values (I.V.) of fat samples obtained from various patients.](numbers indicate the patient code)
The conductivity measurement revealed the potential use of fat with tissues as an electronic measuring device probably in the detection of early stage of obesity in children. The deposition of subcutaneous fat in lower abdomen does not get absorbed easily by dieting and exercise, as compared to the upper abdomen. The anatomical and physicochemical properties of subcutaneous fat differ in their physicochemical properties. It was found that the difference in absorption of subcutaneous fat of upper and lower abdomen is due to difference in certain physicochemical and anatomical properties of subcutaneous fat of upper and lower abdomen was the objective and the preliminary results are encouraging. This may pave way for probing the reason for the deposition of fat at the abdomen (Table 3, Fig 3).

**Table 3:** CT Scan Observations of the Anatomy of Superficial Fascia at Level 1. (Midway between umbilicus and xiphisternum)

<table>
<thead>
<tr>
<th>Type of Fascia</th>
<th>Lateral to midclavicular line (front)</th>
<th>Medial to midclavicular line (front)</th>
<th>Lateral to vertical line drawn (Body)</th>
<th>Medial to vertical line drawn (Body)</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>15% (59/380)</td>
<td>21% (79/380)</td>
<td>41% (141/350)</td>
<td>67% (87/130)</td>
</tr>
<tr>
<td>II</td>
<td>1% (4/200)</td>
<td>12% (24/190)</td>
<td>3% (11/350)</td>
<td>2% (10/390)</td>
</tr>
<tr>
<td>III</td>
<td>AbSENT</td>
<td>AbSENT</td>
<td>AbSENT</td>
<td>AbSENT</td>
</tr>
<tr>
<td>IV</td>
<td>AbSENT</td>
<td>AbSENT</td>
<td>1% (9/350)</td>
<td>7% (10/390)</td>
</tr>
<tr>
<td>V</td>
<td>2% (46/380)</td>
<td>21% (14/650)</td>
<td>8% (11/350)</td>
<td>23% (11/490)</td>
</tr>
</tbody>
</table>

**Conclusion:**
1. The superficial fascia of the abdomen was multilayered in the midline. These layers gradually merged with each other and reduced in number laterally. Hence, the disputes regarding the number of layers of the superficial fascia may be the representation of number of layers at their dissection sites.
2. The mean thickness of superficial fascia of lower abdomen was more than upper abdomen in both males and females.
3. The color, shape, size and arrangement of fat lobules were different at different regions of the abdomen.
4. Elastic, collagen and hydroxyproline contents of superficial fascia of upper abdomen were more than lower abdomen in both males and females.
5. There was difference in physicochemical properties (surface tension, viscosity, specific gravity, conductivity, iodine value, thermal properties) of subcutaneous fat of upper and lower abdomen. This may be the reasons for different behavior of subcutaneous fat towards resorption (12).

The present study therefore attempts to build a normal data base for the different properties of subcutaneous fat & superficial fascia of human abdomen. This data can be extrapolated for clinical use.

**Scope for the future work**
1. The study leads to further work on different shapes & size of fat lobules in other areas of the body. The findings of the study of vascularity of fat lobules and correlation with obesity may be interesting.
2. Study of composition of fat and comparison with other areas of the body may be helpful in finding newer ways to manage the obesity.
References:


