ORIGINAL ARTICLE

“FACTORS AFFECTING THE ADHERANCE OF POST CABG PATIENTS IN CARDIAC REHABILITATION-A CROSS-SECTIONAL STUDY IN KARACHI”

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ABSTRACT
Cardiovascular disease (CVD) is the principal cause of death globally. To decrease this mortality rate, a wide-ranging program from hospital discharge to highly structured and monitored exercise therapy is required. Cardiac Rehabilitation (CR) purposed to decrease risks, disability, augment emotional welfare, to implement and follow healthy behavior, thus adopting a healthy life style. This study was aimed to determine the factors that affect adherence of post coronary artery bypass grafting (CABG) patient’s to Cardiac Rehabilitation. This cross-sectional study was conducted on 255 Post CABG patients with age 30 years above. Patients in Phase II and III of CR were interviewed through self-designed structured questionnaire. After taking the informed Consent during their hospital visit in eight hospitals in Karachi. Questioner was self-design structured questions with responses on Likert Scale. Patients in phase I of CR, patients in fitness program, pregnant females, Patients with disability, severe functional impairment and co-morbidities that limit CR participation were excluded. The collected data were entered in and analyze by the Statistical Package for Social Sciences version 20.0 Software (SPSS Inc., Chicago, Illinois). Frequencies and percentages were taken out for all qualitative variables and presented in tabular form. Most patients were referred for CR by the cardiologist (51.0%). A major factor that leads to non-adherence were distance to CR facilities (83.75%), fatigue (83.55%), lack of time (67.8%), lack of transport (62.7%). Other significant factors were illiteracy (42%), financial issues (63.9%), low self-efficacy (64%), low-level of physical fitness (39.6%). Adherence to Phase-II- CR was 52.2%, with no significant differences between men and women. Adherence was observed in patients who have accepted their condition (81.1%), learned to cope with the limitations (76.8%), were comfortable with exercise regime (67.4%), believed that exercise will decrease the deconditioning (74.9%) and will improve physical fitness (20.8%). Major factors were Distance to CR facilities, fatigue, lack of time, lack of transport and financial issues. Other substantial factors were depression, anxiety, helplessness, illiteracy, old age, low self-efficacy, low-level of physical fitness; greater perceived barriers were associated with low-levels of adherence. Decrease perceived benefits and increased barriers increase drop-out rates from cardiac rehabilitation.

Keywords:
Cardiovascular disorders, Cardiac Rehabilitation, Coronary Artery Bypass Grafting, Adherence.

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1. INTRODUCTION
Cardiovascular diseases (CVD) are the one that affects structure and function of the heart and blood vessels. CVD causes for around one third deaths worldwide\(^1\), with the highest figures in countries of South and East Asia\(^2\). There are several methods to control or treat these diseases like lifestyle modification, medications, certain heart procedures or primary, secondary and tertiary cardiac rehabilitation programs\(^3\). These disorders are the leading cause of mortality and morbidity in the industrialized world, accounting for almost 50% of all deaths annually. The survivors constitute an additional reservoir of cardiovascular disease morbidity. In the United States alone, over 14 million persons suffer from some form of coronary artery disease (CAD) or its complications, including congestive heart failure (CHF), angina, and arrhythmias. Of this number, approximately 1 million survivors of acute myocardial infarction (MI), as well as the more than 300,000 patients who undergo coronary bypass surgery annually, are candidates for cardiac rehabilitation.

Cardiac rehabilitation (CR) provides benefits to those who have cardiovascular diseases, heart failure, recent heart attack, heart procedures such as angioplasty and coronary artery bypass (CABG) or certain arrhythmias and implantable devices like pacemaker and defibrillator\(^4\). Cardiac rehab helps patients by making changes in lifestyle that reduces risk factors, improves functions of the heart and vessels, speed up recovery from heart procedures or heart attack, improve ability to perform daily living task and disease management capacity thus 2 improves quality of life\(^5\). CR is responsible for a decrease in mortality rate by 25% in the first year of recovery.\(^7\) Cardiac rehabilitation aims to reverse limitations experienced by patients who have suffered the adverse pathophysiologic and psychological consequences of cardiac events. Cardiac rehabilitation program (CRP) involves patient assessment, exercise training, education, behavior change, psychological, physical activity and diet/nutritional counseling, weight and lipid management, blood pressure monitoring, smoking cessation\(^5\). CR program involves attending 45 outpatient sessions after a month of hospital discharge, consisting of 4 phases. Phase I which is inpatient phase, Phase II is outpatient phase and Phase III and IV are maintenance phases respectively\(^9\). Post-CABG cardiac rehabilitation have many benefits, the most important of these are improved exercise tolerance, enhancements in lipid and lipoprotein levels detected in patients undergoing cardiac rehabilitation exercise training and education. Exercise must be combined with dietetic and medicinal interventions for required lipid and excess weight control, decrease blood pressure and with well-designed educational, counseling, and behavioral modification programs it results in cessation of smoking in a substantial number of patients and augments measures of social and psychological functioning\(^10\). The importance of our study was the outpatient CR service, since it is this component of CR that has been most widely and extensively known to impart benefit to its participants. We selected patients who suffered from CABG surgery and measured their attendance rates at an outpatient CR program. We have studied the CR attendance rates of CABG patients and the impact on attendance of sociodemographic, medicinal, intellectual, psychological factors and topographical barriers, to determine which factors preferred and which destitute adherence to CR\(^11\). Despite these, multifaceted benefits only low percentage of people who have cardiac diseases and cardiac procedures have participated in cardiac rehabilitation programs. In local setting, there are few CR centers available. Additionally, various factors that inhibit patient’s attendance in CRP. We enrolled patients from Phase II till IV\(^12\). Cardiac rehabilitation (CR): It is a secondary outpatient program designed to reduce future heart risks in people with heart diseases. Usually consist of exercise training, psychosocial counseling, physical activity and nutritional management\(^13\). Cardiovascular diseases (CVD): are group of disorders of heart and peripheral blood vessels\(^14\). Coronary heart disease (CHD): also known as ischemic heart disease is a disease of blood vessels supplying the heart muscles, in which narrowing of blood vessel occur due to
deposition of cholesterol on their wall\textsuperscript{15}. Coronary artery bypass graft (CABG): is a type of surgery performed to overcome the blocked portion of coronary artery by inserting a vein or arterial graft to resume the blood supply of the affected area\textsuperscript{16}.

1.2 Phases of cardiac rehabilitation:
Phase-1(inpatient): occurs in hospital following MI or surgical procedure like CABG, starts at day 1 up to week 1 of cardiovascular event\textsuperscript{17}. Phase-2(outpatient): after 2 weeks of cardiovascular event. This delay allows myocardium to heal and monitor patient’s response to new medicine regime. Participants are monitored via telemetry to determine heart rate and rhythm, blood pressure at rest and during exercise, ventilation response are noted\textsuperscript{18}. Phase-3(outpatient maintenance): unsupervised continued fitness regime with regular monthly coordination with cardiac rehabilitation team. Participants are reminded to monitor their own pulse rate\textsuperscript{19}.

2. METHODS
Post CABG subjects in Phase II and III of Cardiac Rehabilitation with age 30 years and above were included. Exclusion Criteria is patients in phase I of cardiac rehabilitation, those who are enrolled in primary prevention or fitness program, pregnant females, patients with disability, Patients with severe functional impairment (neurological, cognitive or joint disease), coexisting co-morbidities hindering in participation at CR were excluded. It was a Cross sectional study design. Non-Probability Purposive sampling technique was used. Duration of study was 8 weeks after approval of synopsis.

Total four hospitals of Karachi having cardiology and cardiac Rehabilitation centers were included. Namely National Medical Center (NMC), Holy family hospital, Institute of Physical Medicine and Rehabilitation (IPM&R) and National Institute Cardio-Vascular Disorder (NICVD). Sample size of 255 was calculated through Open Epi version 3.0 with a hypothesized frequency of 79% (proportion of patients did not proceed to phase II cardiac rehab program), confidence limits of 5%, design effect of 1% and confidence level of 95% 24.

A self-designed structured questionnaire was used to collect the data from subjects attending cardiac rehabilitation. Written informed consent as well as voluntary participation in questionnaire fill up was regarded as consent. The research conforms ethical considerations. The principles of informed consent, privacy, confidentiality and anonymity were applied. All information identifying patients were removed before analysis.

2.1 QUESTIONNAIRE DESIGN: A self-structured Questioner with questions on Likert Scale was designed. It contains five sections with questions on Socio- 14 demographic, clinical characteristics, perceived benefit/barrier of cardiac rehabilitation, patient’s perception on benefit/barrier and on depression/anxiety factors related to CR. First section was of Sociodemographic factors, which included patient name, age, gender, marital status, residential area, referral and occupation. The sociodemographic data was gathered directly from the patient. Second section included patient’s current phase of cardiac rehab and when he joined the CRP, medications and comorbid conditions. Third section included questions on professed benefits or barriers for participation in cardiac rehabilitation by patients. Forth section included patient’s perception on benefits or barriers of cardiac rehabilitation program and fifth section included patient’s level of anxiety or depression during cardiac rehabilitation program. Collected data was entered in and analyze by the Statistical Package for Social Sciences version 20.0 Software (SPSS Inc., Chicago, Illinois). Frequencies and percentages were taken out for all qualitative variables and presented in tabular form and figures.

RESULT:
According to the objective and methodology of the study 255 participants who done their Coronary Artery Bypass Grafting (CABG) recently were included in the study. Regarding their demographic characteristics, most of them (31.8%) were in between the age of 51-60 years, followed by 27.5% between the ages of 41-50 years. Male and females were almost equal in our study. Majority of them (83.5%) were married. Most of them (42.0%) were illiterate. 39.6% were educated up to lower secondary and remaining (18.4%) were more than secondary educated. Information regarding cardiac rehabilitation program were mainly (58.1%) provided either by cardiologist or by their medical team. The other source of information was family or friends. Role of social media and internet was found very low (9.8%) regarding providing information for cardiac rehabilitation program in our study participants. (Table1)
Table 1. Demographic Characteristics of Study Participants

<table>
<thead>
<tr>
<th>Variables</th>
<th>Frequency</th>
<th>Percentages</th>
</tr>
</thead>
<tbody>
<tr>
<td>30-40 years</td>
<td>47</td>
<td>18.4</td>
</tr>
<tr>
<td>41-50 years</td>
<td>70</td>
<td>27.5</td>
</tr>
<tr>
<td>51-60 years</td>
<td>81</td>
<td>31.8</td>
</tr>
<tr>
<td>61-70 years</td>
<td>41</td>
<td>16.1</td>
</tr>
<tr>
<td>Above 70 years</td>
<td>16</td>
<td>6.3</td>
</tr>
</tbody>
</table>

**Age groups**

- Female: 125 (49.0%)
- Male: 130 (51.0%)

**Marital status**

- Married: 213 (83.5%)
- Currently un married: 42 (16.5%)

**Education**

- Un-educated: 107 (42.0%)
- Primary educated: 38 (14.9%)
- Secondary educated: 63 (24.7%)
- Higher Secondary educated: 17 (6.7%)
- Bachelors/Graduate: 18 (7.1%)
- Masters/Post-graduate: 12 (4.7%)

**Information received about cardiac rehab program**

- Cardiologists: 130 (51.0%)
- Medical team: 18 (7.1%)
- Internet: 8 (3.1%)
- Social media: 17 (6.7%)
- Family: 47 (18.4%)
- Friends: 35 (13.7%)

Regarding cardiac rehabilitation characteristics of the participants, 52.2% of the participants were in phase II whereas remaining 47.8% were in phase III of cardiac rehabilitation program. Most of them (40.8%) join the cardiac rehabilitation program after 10 weeks of their hospitalization. Majority of the participants (95.7%) were taking medication whereas 4.3% were not taking the medication. Most of the participants (44.3%) were not suffering with any adverse condition whereas 28.6% were diabetics followed by COPD (respiratory illness) (12.5%) and Renal dysfunction (5.9%). (Table2)
Table 2. Cardiac Rehabilitation Characteristics of Study Participants

<table>
<thead>
<tr>
<th>Variables</th>
<th>Frequency</th>
<th>Percentages</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Phase of Cardiac Rehabilitation</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>PHASE II</td>
<td>133</td>
<td>52.2</td>
</tr>
<tr>
<td>PHASE III</td>
<td>122</td>
<td>47.8</td>
</tr>
<tr>
<td><strong>Join Cardiac rehabilitation program</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4-6 weeks after hospitalization</td>
<td>47</td>
<td>18.4</td>
</tr>
<tr>
<td>7-8 weeks</td>
<td>39</td>
<td>15.3</td>
</tr>
<tr>
<td>9-10 weeks</td>
<td>65</td>
<td>25.5</td>
</tr>
<tr>
<td>Above 10 weeks</td>
<td>104</td>
<td>40.8</td>
</tr>
<tr>
<td><strong>Taking medication</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Yes</td>
<td>244</td>
<td>95.7</td>
</tr>
<tr>
<td>No</td>
<td>11</td>
<td>4.3</td>
</tr>
<tr>
<td><strong>Comorbidities</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Renal dysfunction</td>
<td>15</td>
<td>5.9</td>
</tr>
<tr>
<td>Diabetes</td>
<td>73</td>
<td>28.6</td>
</tr>
<tr>
<td>COPD (respiratory illness)</td>
<td>32</td>
<td>12.5</td>
</tr>
<tr>
<td>Peripheral vascular disorder</td>
<td>2</td>
<td>.8</td>
</tr>
<tr>
<td>None</td>
<td>113</td>
<td>44.3</td>
</tr>
<tr>
<td>More than 1 condition</td>
<td>20</td>
<td>7.8</td>
</tr>
</tbody>
</table>

Study participants were asked through 23 questions regarding physical benefits and barriers to adopt cardiac rehabilitation program. According to the analysis, majority of the participants (67.4%) were either agreed or strongly agreed that they are feel comfortable with exercise. Similarly, majority of them (74.9%) agreed that exercise prevent them from further heart attacks. Majority (73%) were also agreed that it makes them feel relaxed. However, majority participants (75.2%) did not agreed that exercise gave them a sense of personal accomplishment or it provide them a chance to have contact with friends and persons and enjoyed their Company (74.1%). Similarly, majority did not agree with the statements that exercising keeps them away from having high blood pressure (69.4%), increases level of their physical fitness (79.2%), live longer if they do exercise (80.4%), improves their functioning cardiovascular system (77.3%), physical endurance (76.9%), quality of their work (77.2%), or they remained failure to achieve goals in previous attempts to become active (52.1%). Majority of the participants disagreed or strongly disagreed with the statements that their spouse (65.5%) and family members (57.6%) did not encourage them for exercise. Majority (63.9%) agreed that cardiac rehabilitation program is expensive Regarding barriers in cardiac rehabilitation program, majority of the study participants (77.8%) were either agreed or strongly agreed that such exercise takes too much
of their time and it made them tired (84.3%) or they felt fatigued (82.8%) and pain by these exercise (58.8%). They also think that places of cardiac rehabilitation exercise are too far away (83.6%) and the exercise facilities do not have convenient schedules for them (74.1%). Other barriers statements for which they either strongly agreed or agreed were lack of transportation (62.7%), and lack of access to opportunities such as nearby facilities (85.9%). (Table 3)

Table 3. Distribution of Physical Benefit and Barrier in Cardiac Rehabilitation Program of Study Participant

<table>
<thead>
<tr>
<th>Responses</th>
<th>strongly agree</th>
<th>agree</th>
<th>disagree</th>
<th>strongly disagree</th>
</tr>
</thead>
<tbody>
<tr>
<td>I am comfortable with exercise.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>n(%)</td>
<td>87(34.1)</td>
<td>85(33.3)</td>
<td>70(27.5)</td>
<td>13(5.1)</td>
</tr>
<tr>
<td>Exercising takes too much of my time.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>n(%)</td>
<td>98(38.4)</td>
<td>75(29.4)</td>
<td>17(6.7)</td>
<td>65(25.5)</td>
</tr>
<tr>
<td>I will prevent heart attacks by exercising</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>n(%)</td>
<td>100(39.2)</td>
<td>91(35.7)</td>
<td>53(20.8)</td>
<td>11(4.3)</td>
</tr>
<tr>
<td>Exercise tires me.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>n(%)</td>
<td>135(52.9)</td>
<td>80(31.4)</td>
<td>25(9.8)</td>
<td>15(5.9)</td>
</tr>
<tr>
<td>Exercise gives me a sense of personal accomplishment</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>n(%)</td>
<td>3(1.2)</td>
<td>60(23.5)</td>
<td>96(37.6)</td>
<td>96(37.6)</td>
</tr>
<tr>
<td>Places for me to exercise are too far away</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>n(%)</td>
<td>146(57.3)</td>
<td>62(24.3)</td>
<td>39(15.3)</td>
<td>8(3.1)</td>
</tr>
<tr>
<td>Exercising makes me feel relaxed.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>n(%)</td>
<td>94(36.9)</td>
<td>92(36.1)</td>
<td>59(23.1)</td>
<td>10(3.9)</td>
</tr>
<tr>
<td>Exercising lets me have contact with friends and persons I enjoy.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>n(%)</td>
<td>18(7.1)</td>
<td>48(18.8)</td>
<td>89(34.9)</td>
<td>100(39.2)</td>
</tr>
<tr>
<td>Exercising will keep me from having high blood pressure</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>n(%)</td>
<td>10(3.9)</td>
<td>68(26.7)</td>
<td>98(38.4)</td>
<td>79(31.0)</td>
</tr>
<tr>
<td>Exercising increases my level of physical fitness</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>n(%)</td>
<td>3(1.2)</td>
<td>50(19.6)</td>
<td>103(40.4)</td>
<td>99(38.8)</td>
</tr>
<tr>
<td>Statement</td>
<td>n(%)</td>
<td>5(2.0)</td>
<td>45(17.6)</td>
<td>90(35.3)</td>
</tr>
<tr>
<td>---------------------------------------------------------------------------</td>
<td>----------</td>
<td>--------</td>
<td>----------</td>
<td>----------</td>
</tr>
<tr>
<td>I will live longer if I exercise.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Exercise facilities do not have convenient schedules for me</td>
<td>n(%)</td>
<td>122(47.8)</td>
<td>67(26.3)</td>
<td>60(23.5)</td>
</tr>
<tr>
<td>Exercising improves my functioning cardiovascular system.</td>
<td>n(%)</td>
<td>4(1.6)</td>
<td>54(21.2)</td>
<td>105(41.2)</td>
</tr>
<tr>
<td>I am fatigued by exercise.</td>
<td>n(%)</td>
<td>143(56.1)</td>
<td>68(26.7)</td>
<td>28(11.0)</td>
</tr>
<tr>
<td>Pain when I exercise.</td>
<td>n(%)</td>
<td>101(39.6)</td>
<td>49(19.2)</td>
<td>58(22.7)</td>
</tr>
<tr>
<td>My spouse (or significant other) doesn’t encourage exercising.</td>
<td>n(%)</td>
<td>45(17.6)</td>
<td>43(16.9)</td>
<td>85(33.3)</td>
</tr>
<tr>
<td>My physical endurance is improved by exercising.</td>
<td>n(%)</td>
<td>5(2.0)</td>
<td>54(21.2)</td>
<td>120(47.1)</td>
</tr>
<tr>
<td>My family members do not encourage me to exercise.</td>
<td>n(%)</td>
<td>68(26.7)</td>
<td>40(15.7)</td>
<td>88(34.5)</td>
</tr>
<tr>
<td>Exercise improves the quality of my work.</td>
<td>n(%)</td>
<td>3(1.2)</td>
<td>55(21.6)</td>
<td>101(39.6)</td>
</tr>
<tr>
<td>Failure to achieve goals in previous attempts to become active</td>
<td>n(%)</td>
<td>76(29.8)</td>
<td>46(18.0)</td>
<td>109(42.7)</td>
</tr>
<tr>
<td>Lack of transportation.</td>
<td>n(%)</td>
<td>137(53.7)</td>
<td>23(9.0)</td>
<td>38(14.9)</td>
</tr>
<tr>
<td>Do you think Cardiac Rehabilitation Program is expensive?</td>
<td>n(%)</td>
<td>125(49.0)</td>
<td>38(14.9)</td>
<td>57(22.4)</td>
</tr>
<tr>
<td>Lack of access to opportunities such as nearby facilities.</td>
<td>n(%)</td>
<td>182(71.4)</td>
<td>37(14.5)</td>
<td>22(8.6)</td>
</tr>
</tbody>
</table>
Fig. 1. Physical barriers / benifits

Fig. 2. Physical barriers / benifits
The participants of the study were also asked 8 questions regarding cognitive benefits and barriers in cardiac rehabilitation program. Majority of the participants agreed or strongly agreed with the statements that dealing with the illness made them a strong person (76.1%), or they have learned a great deal from their illness (93.3%) and their illness had made life more precious to them (96.1%). However, majority of the participants were agreed or strongly agreed with the statements that their illness control their life (64.0%), their illness limits them in everything that was important to them (65.1%) and their illness frequently makes them feel helpless (52.6%). Majority of subjects also agreed that they have learned to accept the limitations imposed by their illness (81.1%) and they can cope effectively with their illness (76.8%). (Table4)
Lastly, level of anxiety or depression in cardiac rehabilitation program was also assessed through 4 item questions from the study participants. Majority of the participants (66.3%) either agreed or strongly agreed that they had Tension (feelings of tension, fatigability, startle response, feelings of restlessness, inability to relax during their exercise) and they also have Intellectual problem (difficulty in concentration during exercise, and poor memory to remember exercise) (57.6%). Similarly, majority (83.5%) were also agreed to felt cardiopulmonary symptom (tachycardia, palpitations, pain in chest, throbbing of vessels, fainting feelings, missing beat, Pressure or constriction in chest, choking feelings, sighing and dyspnea during exercise). However, majority (58.8%) were disagree or strongly disagreed with to having somatic symptoms (felt Pains and aches, twitching, stiffness, unsteady voice, Tinnitus, blurring of vision, hot and cold flushes, feelings of weakness, pricking sensation during exercise). (Table5)
Table 5. Distribution of Anxiety or Depression Barriers in Cardiac Rehabilitation Program of Study Participants

<table>
<thead>
<tr>
<th>Options</th>
<th>strongly agree</th>
<th>agree</th>
<th>disagree</th>
<th>strongly disagree</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Tension</strong>- (Feelings of tension, fatigability, startle response, feelings of restlessness, inability to relax during exercise.)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>n(%)</td>
<td>77(30.2)</td>
<td>92(36.1)</td>
<td>51(20.0)</td>
<td>35(13.7)</td>
</tr>
<tr>
<td><strong>Intellectual difficulties</strong>- (Difficulty in concentration during exercise, poor memory to remember exercise.)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>n(%)</td>
<td>74(29.0)</td>
<td>73(28.6)</td>
<td>45(17.6)</td>
<td>63(24.7)</td>
</tr>
<tr>
<td><strong>Somatic symptoms</strong>- (Pains and aches, twitching, stiffness, unsteady voice, Tinnitus, blurring of vision, hot and coldflushes, feelings of weakness, pricking sensation.)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>n(%)</td>
<td>55(21.6)</td>
<td>50(19.6)</td>
<td>75(29.4)</td>
<td>75(29.4)</td>
</tr>
<tr>
<td><strong>Cardiopulmonary Symptoms</strong>- (Tachycardia, palpitations, pain in chest, throbbing of vessels, fainting feelings, missing beat, Pressure or constriction in chest, choking feelings, sighing, dyspnea.)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>n(%)</td>
<td>100(39.2)</td>
<td>113(44.3)</td>
<td>19 (7.5)</td>
<td>23(9.0)</td>
</tr>
</tbody>
</table>

Fig. 5. Anxiety / Depression
Table 6: Distribution of Physical, Cognitive Barrier and Benefit and Level of Anxiety or Depression in Cardiac Rehabilitation Program of Study Participants

<table>
<thead>
<tr>
<th>Variables</th>
<th>Frequency</th>
<th>Percentages</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Physical Barrier in cardiac rehabilitation</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mild</td>
<td>108</td>
<td>42.4</td>
</tr>
<tr>
<td>Moderate</td>
<td>147</td>
<td>57.6</td>
</tr>
<tr>
<td><strong>Cognitive Barrier in cardiac rehabilitation</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mild</td>
<td>24</td>
<td>9.4</td>
</tr>
<tr>
<td>Moderate</td>
<td>231</td>
<td>90.6</td>
</tr>
<tr>
<td><strong>Level of anxiety or depression in cardiac rehabilitation</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mild</td>
<td>97</td>
<td>38.0</td>
</tr>
<tr>
<td>Moderate</td>
<td>158</td>
<td>62.0</td>
</tr>
</tbody>
</table>

4. CONCLUSION
Major barriers to cardiac rehabilitation were unavailability of nearby rehabilitation centers, fatigue, and lack of time, transport issues, financial issues and anxiety/depression. Attempts should be made to minimize the barriers as it will increase the adherence to cardiac rehabilitation. Better adherence was seen in patients who believed in the benefits of exercise. Factors reducing participation in CRP are wide-ranging but are modifiable.

FUNDING
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CONFLICT OF INTEREST
The authors declare no conflict of interest

ETHICAL APPROVAL
A prior consent was taken in writing from the all patients

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Factors Are Involved? International Journal of Clinical Medicine, 6, 605-614
ORIGINAL ARTICLE

PERIODONTAL DISEASE STATUS AMONG ADULT POPULATION ATTENDING PRIVATE DENTAL HOSPITAL AT GADAP TOWN KARACHI

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1Department of Community Dentistry, Baqai Dental College, Baqai Medical University, Karachi, Pakistan.

ABSTRACT

The purpose of this study was to evaluate the periodontal disease status among adult population of private dental clinic of outpatient department Karachi. It was descriptive cross sectional study. A brief study protocol was explained and verbal Informed consent was obtained from each study participants before the oral examination. The examination of oral cavity was carried out according to the World’s Health Organization oral health survey form (1997) using an examination instruments and CPITN probe under proper light source. The data was analyzed by using statistical package for social sciences SPSS 20 version. A total of 104 study participants. The mean age was 2.09 and standard deviations showed 0.837, along with the three age groups were 20-25 (30.8%), 26-35 (29.8%), and 36-45 (39.4%). However, the individuals were doing private job were 44.2%, governments job peoples was 14.4%, businessman persons were 1.9%, jobless individuals were 4.8%, those women’s are housewives were 32.7% and other jobs doing participants like tailor, labor-man, shopkeepers etc., were 1.9%. According to the community periodontal index (CPI) the patients who had diagnosed with bleeding gums were 22.1% this result showed that gingivitis was seen in this rural community of Gadap town, likewise, those patients who attended the dental hospital OPD that have a poor oral hygiene noticed that plaque and calculus deposition was seen during the oral examination were 52.9%. A few personnel who attended the dental clinic in the hospital they had a periodontal pocket depth 4-5mm and gingivitis were 3.8%.

KEY WORDS: Periodontal Disease, Private Dental Hospital, Out Patient Department

INTRODUCTION

Oral health is an essential part of general health and an important advantage for any human being. Periodontal diseases are a collection of chronic, progressive bacterial infections resulting in inflammation and destruction of tooth supporting tissues. (1) Its impact on individuals and communities in conditions of pain, distress, impairment of function, and reduced quality of life is significant. In addition a variety of demographic factors such as socioeconomic status and level of learning can influence the development of periodontal disease. (2)

Quite a lot of epidemiological studies comprise of gums disease and its related to the structures is as older as humankind. It continues to be one of the most frequent diseases. There is a broad variation in the periodontal status of individuals living in different geographic locations which could be assigned to difference between the life styles and oral hygiene practices. (3)

Periodontal diseases are one of the most frequent importances among oral health conditions affect the populations around the globe. These are the most important cause of tooth loss mainly among the aged people and its considerably representing a community health problem. (4) In several studies widespread the dental plaque development and in?ammation of gingival tissue are universally and strongly associated with the age, gender and ethnic identity. (5) The predominance of periodontitis is significantly high in the developing countries. (6)

Moreover the most necessary oral health education and simple intervention like pain relief and emergency care for sensitive infection and distress are not accessible to the huge preponderance of population. (7)
These days usually decided that approximately all types of periodontal diseases occur as an outcome of varied microbial infection surrounded by the particular group of pathogenic bacteria can exists. (8-9) In another study evidence is reviewed previously on the possible roles of adaptable and non adjustable risk factors linked with the periodontal disease and an thoughtful risk factors is important for clinical practices. (10) The purpose of this study was to evaluate the periodontal disease status among adult population of private dental clinic of outpatient department Karachi.

**MATERIAL AND METHODS**

The 104 participants, who were divided into three groups aged 15-24 years were qualified to group one, group two aged from 25-35 years, and group three aged 36-45. The subjects in every group were male and female. Descriptive cross sectional study design. A brief study protocol was explained and verbal Informed consent was obtained from each study participants before the oral examination. The examination of oral cavity was carried out according to the World’s Health Organization oral health survey form (1997) using an examination instruments and CPITN probe under proper light source. The periodontal status was evaluated by Community Periodontal Index of Treatment Need (CPITN). The oral cavity was divided into 6 sextants, consisting of maxillary and mandibular molars, premolars, incisors and canines. One tooth in each sextant was examined for presence of gingival bleeding (code 1), calculus (code 2) and periodontal pocket (code 3 if its depth was 3.5-5.5 mm, and code 4 if it was 6mm or deeper). Code 0 means healthy periodontium. The examination was carried out on maxillary, mandibular first molars, maxillary and mandibular central incisors. The WHO oral health assessment survey form was used to record the data. The data was analyzed by using statistical package for social sciences SPSS 20 version.

**RESULTS**

A total of 104 study participants the male individuals were 58.7% and 41.3% were female participants respectively. The mean age was 2.09 and standard deviations showed 0.837, along with the three age groups were 20-25 (30.8%), 26-35 (29.8%), and 36-45 (39.4%). However, the individuals were doing private job were 44.2%, governments job peoples was 14.4%, businessman persons were 1.9%, jobless individuals were 4.8%, those women’s are housewives were 32.7% and other jobs doing participants like tailor, labor-man, shopkeepers etc., were 1.9%.

Those individuals who lived in urban area were 24%, those persons that lived in peri-urban area were 44.2% and those personnel who lived in rural area of Gadap town were 30.8%. According to the community periodontal index (CPI) the patients who had diagnosed with bleeding gums were 22.1% this result showed that gingivitis was seen in this rural community of Gadap town, likewise, those patients who attended the dental hospital OPD (Outpatient department) that have

<table>
<thead>
<tr>
<th><strong>TABLE: 1 SIGNIFICANT RESULTS OF PERIODONTAL DISEASE INDEX</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Community Periodontal Index</strong></td>
</tr>
<tr>
<td>---------------------------------------------------------------</td>
</tr>
<tr>
<td>Healthy</td>
</tr>
<tr>
<td>Bleeding</td>
</tr>
<tr>
<td>Calculus</td>
</tr>
<tr>
<td>Pocket depth 4-5mm</td>
</tr>
<tr>
<td><strong>Total</strong></td>
</tr>
</tbody>
</table>
a poor oral hygiene noticed that plaque and calculus deposition was seen during the oral examination were 52.9%. A few personnel who attended the dental clinic in the hospital they had a periodontal pocket depth 4-5mm and gingivitis were 3.8%.

The patients who were came to the department of periodontology; after clinical examination of oral cavity had been done with the CPI probe they had observed a 0-3mm loss of periodontal attachment and with periodontitis were 37.5%. Then those individuals had 4-5mm loss of periodontal attachment 32.7% were noticed in a population of Gadap town, 26.9% persons had 6-8mm loss of periodontal attachment were observed after the clinical examination of oral cavity was diagnosed with gingivitis and periodontitis. A small number of patients who had 9-8mm loss of periodontal attachment were 2.9% respectively.

According to the age groups of 15-45 years participated in this study there were had a large number of patients they diagnosed with the periodontal disease in the community of Gadap town area.

DISCUSSION
The oral lesions are easy to prevent by primary preventive measures; lack of oral hygiene lead to tooth loss which is a public health issue across the globe that affects individuals of all ages and dental plaque has main function in initiating dental caries, gingivitis, and periodontal problems and consider as the cause in most of the dental diseases and its removal is necessary for healthy dental tissue. A path- finder study done in Pakistan under auspices of WHO shows that among kids of 12-15 years of age group, 32% had healthy periodontium in year 1991. The findings of this study are suggestive of the fact that since the path finding survey was done in Pakistan, nothing has been done in this regard to improve the oral health. It has been seen that there is a wide difference in the periodontal status of urban and rural population as seen in different research studies. This cross-sectional survey was conducted to accessing the periodontal disease status among adults as well as elderly individuals of Gadap town area.

Another study showed that the results concerning periodontal diseases are more common in males where trends were higher for gingivitis (51%) and periodontitis (10%) which when compared with females who have relatively lower percentages with gingivitis occurring in 29% and periodontitis occurring in 5% individuals. These findings were in accordance with previous studies which reported that males are more severely affected with periodontal disease than females. As compared in our study the 22.1% study subjects had diagnosed with gingivitis and 26.9% individuals had periodontitis and loss of periodontal attachment were noticed. On the contrary, periodontal status seems to have further deteriorated. It is not very unlikely that if samples from population of other rural areas are studied, similar results will be achieved. Leaving the situation in situ at this alarming stage will put general health of the rural population in jeopardy as it has been documented that periodontal diseases are strongly associated with Carotid Atherosclerosis, risk of adverse pregnancy consequences, respiratory diseases and diabetes mellitus. The foremost reason for prevalence of such high periodontal ailments in Gadap population may be its socioeconomic status as the impact of socioeconomic standing of a person plays a substantial role in retaining or not retaining good oral health. The other collaborating factors may be illiteracy, cultural constraints, lack of public policies, restricted resources of the health sector, low human development in the country, competing health priorities and low-priced accessibility of betel quid and areca nut. WHO introduced The Community Periodontal Index (CPI) to provide profiles of periodontal health status in countries and to facilitate them to plan interventional programs for effective control of periodontal disease. In the past twenty years, numerous countries have provided CPI data to be kept in the WHO Global Oral Health Data Bank and they are displayed through WHO Country/Area Profile Program (CAPP) by University of Niigata, Japan. It is surprising to note that in the latest display of periodontal profile of countries by Niigata University, CPI of Pakistan is not included. The reason behind may be lack of valid and authentic data by any competent authority or professional
organization. This study suggests rising prevalence of periodontal disease and indicating higher periodontal treatment needs for the population. The data strongly recommends that it is timely and prudent that the disease is given its due attention and CPI of Pakistan is introduced. Evaluation using these indices will help in identifying and classifying periodontal disease rapidly thus periodontal treatment needs can be assessed. 17

CONCLUSION
Prevalence of periodontal diseases especially in rural youth is very high due to low socio-economic status, low medical education background, and negative attitudes towards oral hygiene skills and dental services that why it requires immediate attention of the concerned authorities before disease burden becomes unmanageable.

LIMITATION
The prevalence of female respondent was lower as compared to male in this study, it could be the reason that dental hospital timing was at morning, on this moment most of the female spend their time at their household due to this reason that do not have time to access to dental clinic for dental treatments as compared to the male.

FUNDING
None mentioned

CONFLICT OF INTEREST
The authors declare no conflict of interest.

REFERENCES:
ORIGINAL ARTICLE

PHOTOLYSIS OF ASCORBIC ACID IN AQUEOUS SOLUTION: A KINETIC STUDY

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2Faculties of Pharmaceutical Sciences, Riphah International University, Islamabad, Pakistan
3Faculty of Pharmacy, Jinnah University for Women, Karachi, Pakistan

ABSTRACT:
The kinetics of photolysis of ascorbic acid in aqueous solution on UV irradiation has been studied in the pH range 1–11 and the apparent first–order rate constants for the degradation reactions have been determined. The k–pH profile for the photolysis in the acid range is represented by a sigmoid curve indicating the gradual ionization of the molecule (AH₂) to ascorbyl anion (AH¹). Ascorbic acid shows maximum stability around pH 5–6 due to the lowest rate of oxidation reduction of the mono–anion form. The rate of photolysis is increased up to sevenfold at pH 10.0, compared to that at pH 5.0, due to an increase in the redox potentials with pH leading to faster oxidation of the anionic species to dehydroascorbic acid in the alkaline range. The rate is very slow in the pH range 1–2 due to the existence of the non–ionized form. The apparent first–order rate constants for the photolysis of ascorbic acid at pH 1–11 range from 0.057–3.948×10⁻² min⁻¹. A scheme for the sequence of reactions involved in the photolysis of ascorbic acid is presented.

Keywords: Ascorbic acid, Ascorbyl anion, Rate–pH profile, Spectrometric assay.

INTRODUCTION:
Ascorbic acid (AH₂)(1) (Fig. 1) is an essential micronutrient and performs important metabolic functions in humans.9–15 It is sensitive to air and light8 and is degraded by chemical or Photooxidation. The stability of ascorbic acid has been studied in total parenteral nutrition (TPN) solutions,16–19 infusion solutions,20–41 plant material,42–44 biological fluids,45–48 and milk.49–51 Attempts have been made to stabilize ascorbic acid by the use of various agents in aqueous solutions,52–55 vitamin preparations,56–60 cosmetic preparations,61–66 food products,63–67, and 68 and by chemical derivatization.69–70 An important consideration in the stability of AH₂ in TPN solutions is the generation of hydrogen peroxide in the presence of light.71–75 This may result from the oxidation of ascorbyl anion by molecular oxygen76–80 and may further be involved in the degradation of AH₂.81–83 The kinetics and mechanism of oxidation reactions of AH₂ have been studied by several workers.44, 52, 77, 79, 84–91.

* Corresponding Author Email: zubair_ana@hotmail.com
AH₂ is a well-known antioxidant and acts as an inhibitor of Photooxidation of a number of drugs and biological compounds by quenching the singlet oxygen \(^{96-110}\). The singlet oxygen \(\text{O}_2^+\) is highly reactive, electrophilic and non-radical specie. It can be produced from triplet oxygen \(\text{O}_2^\text{t} \) by photosensitization in the presence of light\(^{111}\). The oxidation reactions mediated by \(\text{O}_2^+\) are very rapid due to the low activation energy required and the reaction rates are much greater than those caused by \(\text{O}_2^\text{t} \). AH₂ also plays an important role in inhibiting the photosensitization processes and thus protects the substrates from degradation\(^ {80,113-117}\). In view of the biochemical importance, photosensitivity and extensive use of AH₂ in liquid vitamin preparations / TPN solutions\(^7\) and its high susceptibility to oxidation, the present work has been undertaken to study the photolysis of the vitamin over a wide range of pH and to determine the rate–pH profile to ascertain the range of optimum stability for liquid preparations. The \(k\)--pH profiles for the photolysis of cyanocobalamin\(^ {118-120}\), riboflavin\(^ {121,122}\), folic acid\(^ {123}\), AH₂ in the presence of nicotinamide\(^ {124}\) and for the hydrolysis of 7,8-dimethyl 1,10-(formylmethyl) isoalloxazine (major intermediate in the photolysis of riboflavin)\(^ {25}\) have been reported. The object of this work is to conduct a detailed study of the photolysis of AH₂ in a wide pH range on UV irradiation, identification of the photoproducts formed, and determination of the rate constants, study of rate–pH profile and proposal of a mode of AH₂ photodegradation reactions.

**MATERIALS AND METHODS:**

AH₂ and dehydroascorbic acid (DHA) \((2)\) (Fig. 1) were obtained from Sigma Chemical Co. 2, 3-diketogulonic acid (DKA) \((3)\) (Fig. 1) was prepared by the method of Homann and Gaffron\(^ {76}\). All reagents and solvents were of the purest form available from BDH/Merck. The following buffer systems were used throughout the study:

- KCl–HCl, pH 1.0–2.0;
- Citric acid–Na₂HPO₄, pH 2.5–8.0;
- Na₂B₄O₇–HCl, pH 8.5–9.0;
- Na₂B₄O₇–NaOH, pH 9.5–10.5;
- Na₂HPO₄–NaOH, pH 11.0;

The ionic strength was 0.002 M in each case.

**Photolysis:**

A 10⁻⁴ M aqueous solution of AH₂ (200 ml) at an appropriate pH, contained in a 250 ml beaker (Pyrex), was placed in a water bath maintained at 25°C and irradiated with a Philips 15 W TUV tube \( (51.3\% \text{ emission at } 265\text{nm}, \text{ absorption maxima of } \text{AH}_2 \text{ at pH } 4–11) \) fixed horizontally at a distance of 25 cm from the center of the beaker. The solution was in free equilibrium with air and samples were withdrawn at appropriate intervals for thin-layer chromatographic examination and spectrometric assay.

**Thin-Layer Chromatography (TLC):**

The photolyzed solutions of AH₂ were subjected to TLC using 250-im silica gel GF\(_{254}\) plates using the following solvent systems:

- **A)** Acetic acid–acetone–methanol–benzene (5:5:20:70, v/v/v/v)\(^ {126}\);
- **B)** Ethanol–10% acetic acid (90:10, v/v)\(^ {127}\);
- **C)** Acetonitrile–butyl nitrile–water (66:32:2, v/v/v)\(^ {128}\).

The spots were detected under UV light \((254 \text{ nm})\) (AH₂) or by spraying with a 3% aqueous phenyl hydrazine hydrochloride solution (DHA, DKA).

**Spectral Measurements:**

All spectral measurements on freshly prepared AH₂ and the photolyzed solutions were carried out on a Shimadzu UV-240 spectrometer using quartz cells of 10mm pathlength.

**Light Intensity Measurements:**

The intensity of the Philips 15 W TUV tube was determined by potassium ferrioxalate actinometry\(^ {129}\) as \(3.100.16\times10^{10}\) quanta s\(^ {−1}\).

**Assay Method**

A 5ml aliquot of the photolyzed solution was placed in a 20 ml beaker and the pH was adjusted to 2.0 with 0.1–1.0 M HCl or NaOH solution. The solution was quantitatively transferred to a 10 ml volumetric flask and made up to volume with 0.2 M KCl–HCl buffers (pH 2.0). The absorbance of the solution
was measured at the maximum at 243 nm and the concentration of AH$_2$ was determined using 9980 M$^{-1}$ cm$^{-1}$ as the value of molar absorptivity at the analytical wavelength.

RESULTS AND DISCUSSION:
**Photoproducts of Ascorbic Acid**
The photolysis of AH$_2$ in aqueous solution leads to the formation of degradation products which have been identified by TLC using solvent systems A, B and C. The following products were identified on comparison of their R$_f$ values and spot color with those of the authentic compounds.
pH 1–8: DHA
pH 8–11: DHA, and DKA.
DHA is obtained by the Photoperoxidation of AH$_2$ and DKA by the hydrolysis of DHA. The formation of these products has been observed in the photooxidation$^{76,130,131}$, chemical oxidation$^{132-138}$, and biotransformation$^{138,139-142}$ of AH$_2$. In the presence of light, DHA is converted to the hydrated bi-cyclic hemiketal form at pH 2$^{143}$. Ascorbate free radicals have been detected in the transition metal-dependent oxidation of AH$_2$ by ESR$^{144}$.

**Assay of AH$_2$**
AH$_2$ exhibits absorption maxima at 243 nm (pH 2) and 265 nm (pH 4–10)$^7,8,145$. Spectrometric methods have been used for the assay of AH$_2$ in aqueous solutions at 244 nm (pH ~2)$^{85}$, 245 nm (pH 3.5)$^{52}$, 265 (pH 7)$^{146}$, 275 nm (pH 4.1 and 7.0)$^{147}$, 265 nm (pH 7)$^{148}$, 245 nm (pH ~2)$^{149}$, and 265 nm (pH ~7)$^{48}$. DHA and DKA do not significantly absorb in this region$^{150-152}$ and, therefore, do not interfere with the assay of AH$_2$ in photolyzed solutions.

In the present study, the photolysis reactions of AH$_2$ have been carried out at 10$^{-4}$ M concentration and the assays have been performed at 243 nm after suitable dilution of the degraded solutions (2.0–5.0×10$^{-5}$ M) at pH 2.0 (0.2 KCl–HCl buffer). The validity of Beer’s law relation in the concentration range used was confirmed prior to the assay. The calibration data for AH$_2$ at the analytical wavelength are presented in Table 1. The correlation coefficient ($R^2=0.999$) indicates a good linear relationship over the concentration range employed. The value of molar absorptivity at 243 nm determined from the slope of the calibration curve is in good agreement with those reported by Davies et al.$^{151}$ and Sweetman$^7$. The method has been found satisfactory for the assay of AH$_2$ in degraded solutions and has been applied to evaluate the kinetics of photolysis reactions.

**Table 1. Calibration data for ascorbic acid showing linear regression analysis (n = 5)**

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\lambda_{\text{max}}$</td>
<td>243 nm</td>
</tr>
<tr>
<td>Concentration range (M $\times$ 10$^{-5}$)</td>
<td>2.0–8.0</td>
</tr>
<tr>
<td>Slope</td>
<td>9980</td>
</tr>
<tr>
<td>SE of slope</td>
<td>1.502</td>
</tr>
<tr>
<td>Intercept</td>
<td>0.002</td>
</tr>
<tr>
<td>Correlation coefficient ($R^2$)</td>
<td>0.9999</td>
</tr>
</tbody>
</table>

3.3. **Spectral Characteristics of Photolyzed Solutions**
A typical set of absorption spectra of AH$_2$ solution photolyzed at pH 6.0 is shown in Fig. 2. There is a gradual loss of absorbance at 265nm, with time, due to oxidation of the molecule to DHA which does not absorb in this region. Similar spectral changes are observed on the photolysis of AH$_2$ throughout the pH range 1–11. However, the magnitude of these changes varies with pH and the loss of absorbance for a fixed interval of time increases with pH indicating the increase in the rate of photolysis.

![Fig. 2. Spectral changes during the photolysis of 8×10$^{-5}$ M ascorbic acid at pH 6.0. Irradiation time: 0 to 360 min.](image-url)
Redox and Acid–Based Equilibria of AH₂

The redox and acid-based equilibria of AH₂ are shown in Fig. 3. It is evident that a number of ionic and non-ionic species, depending upon the pH of the medium, are involved in the oxidation–reduction of AH₂ and may play an important role in the photolysis of the molecule. A reaction scheme showing the participation of some of these species

Fig. 3. Redox and acid-based equilibria of ascorbic acid.

Rate–pH Profile of AH₂

The philosophy and types of kinetic pH profiles have been discussed by Carstensen. The major goals of a pH profile are to determine the optimal pH range and to select the best buffer system for a liquid formulation. Several workers have studied the rate–pH profiles of the oxidation of AH₂ in the pH range 2–7, however, the kinetics of Photooxidation of AH₂ in aqueous solution has not been reported. In view of the sensitivity of AH₂ to oxidation, it is necessary to study the photochemical behavior of the vitamin in aqueous solutions to determine the pH range of optimum stability.

The chemical oxidation of AH₂ in aqueous solution is pH-dependent and proceeds by a first-order reaction. The maximum rate of oxidation has been observed at pH 4 near the pKₐ of AH₂ and the minimum rate at pH 5–6 in the acid region. In this region, the molecule exists mostly in the mono-anion form and the delocalization of the electrons renders it relatively stable towards redox reactions.

The oxidation of AH₂ involves mainly the participation of ionized form and the rate of oxidation varies linearly with the concentration of the mono-anionic species. The oxidation steps of AH₂ reaction have been studied by voltammetry.

The k–pH profile for the photolysis of AH₂ at pH 1–11 is shown in Fig. 4 and the rates are reported in Table 2. The reaction in the pH range 1–6 is represented by a sigmoid curve indicating the gradual ionization of the molecule (pKₐ 4.1) with pH and the reactions of the fractions of un-dissociated AH₂ and monohydrate ascorbate anion (AH⁻) present in the pH range. Thus the AH⁻ species appears to be more susceptible to Photooxidation than the AH₂ molecule. The behavior of AH₂ on Photooxidation in the acid region is similar to that observed for the chemical oxidation of AH₂ by molecular oxygen and involves the interaction of AH₂ with singlet oxygen. The AH species (predominant in the pH range 4.2–7.0, 55.7–99.9%) is more reactive toward singlet oxygen than its protonated form, the AH₂ molecule, as suggested by Bisby et al. and, therefore, the rate of Photooxidation is higher in the pH range above pH 4.1 corresponding to the pKₐ of AH₂. A seven-fold increase in the rate at pH 10.0 compared to that at pH 5.0 has been observed. The gradual further increase in the rate of Photooxidation in the pH range 7–10 is consistent with existence of AH⁻ species in the solution. Above pH 10, the rate of Photooxidation slows down due to gradual deprotonation of AH species to give A²⁻ (DHA) species (pKₐ 11.6) which does not appear to undergo any photochemical change. Below pH 2, the rate of oxidation is very slow due to the existence of the molecule in the un-dissociated form (99.9%, pH 1.0).

Fig. 4. k–pH profile for the photolysis of ascorbic acid in aqueous solution.
The Photooxidation of AH₂ is also influenced by its redox potentials which vary with pH. The greater photo stability of AH₂ at pH 5–6, compared to that at pH 10, is due to its lower rate of oxidation-reduction in the acid range (E pH 5.0 = +0.127 V). The increase in the rate of Photooxidation, with pH, is due to a corresponding increase in the redox potentials (E pH 7.0 = +0.058 V)\(^{161}\) of AH₂ which is similar to the photolysis behavior of riboflavin at pH 5–6, compared to that at pH 10.0\(^{21,162}\). Since the ionization as well as the redox potentials of AH₂ is function of pH, the rate of Photooxidation depends upon the species present and its redox behavior at particular pH.

**Table 2.** Apparent first-order rate constants for the photolysis of ascorbic acid at pH 1.0–11.0

<table>
<thead>
<tr>
<th>pH</th>
<th>(k \times 10^2) (min(^{-1}))</th>
<th>(R^2)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.0</td>
<td>0.057</td>
<td>0.999</td>
</tr>
<tr>
<td>2.0</td>
<td>0.085</td>
<td>0.998</td>
</tr>
<tr>
<td>3.0</td>
<td>0.155</td>
<td>0.999</td>
</tr>
<tr>
<td>4.0</td>
<td>0.345</td>
<td>0.998</td>
</tr>
<tr>
<td>5.0</td>
<td>0.534</td>
<td>0.998</td>
</tr>
<tr>
<td>6.0</td>
<td>0.755</td>
<td>0.999</td>
</tr>
<tr>
<td>7.0</td>
<td>0.917</td>
<td>0.999</td>
</tr>
<tr>
<td>8.0</td>
<td>1.049</td>
<td>0.999</td>
</tr>
<tr>
<td>8.5</td>
<td>1.300</td>
<td>0.998</td>
</tr>
<tr>
<td>9.0</td>
<td>1.671</td>
<td>0.998</td>
</tr>
<tr>
<td>9.5</td>
<td>2.929</td>
<td>0.999</td>
</tr>
<tr>
<td>10.0</td>
<td>3.765</td>
<td>0.999</td>
</tr>
<tr>
<td>10.5</td>
<td>3.920</td>
<td>0.998</td>
</tr>
<tr>
<td>11.0</td>
<td>3.948</td>
<td>0.998</td>
</tr>
</tbody>
</table>

**Primary Photochemical Reactions in the Oxidation of AH₂**

Several schemes have been proposed for the chemical and Photooxidation of AH₂ under different conditions. A reaction scheme based on general photochemical principles for the important reactions involved in the Photooxidation of AH₂ is presented below:

According to this reaction scheme, the ground state AH₂ species (\(^0\)AH₂, \(^{1}\)AH) are excited to the lowest singlet state (\(^1\)AH₂, \(^1\)AH) by the absorption of a quantum of UV light [1,5]. These excited states may directly be converted to photoproducts [2,6] or may undergo intersystem crossing (isc) to form the excited triplet states [3,7]. The excited triplet may then degrade to photoproducts [4,8]. The triplet monoaescorbate ion (\(^3\)AH) may react with the ground state AH₂ (\(^0\)AH₂) to form a monoaescorbate anion radical (AH⁻) and a monoaescorbate radical (AH⁺) [9]. The two AH⁺ species may lead to one oxidized and one reduced AH₂ species [10]. AH₂ triplet (\(^3\)AH₂) may react with molecular oxygen (\(^3\)O₂) to yield singlet oxygen (\(^1\)O₂) [11] which may be quenched by the monoaescorbate anion (AH⁻) to form the excited triplet state (\(^3\)AH₂) [12] or by the monovalent ascorbate radical to form an oxidized radical (AHOO) [13]. The oxidized radical (AHOO) may react with ground state \(^0\)AH₂ to form the monoaescorbate radical (HA⁻) and AHOOH [14]. AHOOH may be converted chemically to dehydroascorbic acid (A) and hydrogen peroxide [15]. Hydrogen peroxide may again react with the AH₂ triplet to form the oxidized species (A) [16].

**CONCLUSION:**

The photolysis of AH₂ in aqueous solution at pH 1–11 by UV radiation may be represented by a sigmoid curve. The main species involved in the
photolysis is the monohydrogen ascorbate anion and the optimum stability is exhibited in the pH range 5–6, the region most suitable for the formulation of pharmaceutical preparations. The increase in the rate of photolysis, with pH, is due to an increase in the redox potentials of AH₂ and the species involved. The monohydrogen ascorbate anion of AH₂ is much more susceptible to photolysis than the non–ionized molecule (pH 1–2) and the rate is slowed down in the pH range 10–11 due to the gradual formation of ascorbate anion. The photolysis of AH₂ in the pH range 1–11 is a function of the ionization and redox potentials of AH₂.

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CONFLICT OF INTEREST:
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ETHICAL APPROVAL:
Not applicable

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REVIEW ARTICLE

ERYTHROCYTE SEDIMENTATION RATE:
A USEFUL TOOL IN DIAGNOSTIC APPROACH

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4Khawaja Muhammad Safdar Medical College, Sialkot.

ABSTRACT

Erythrocytes Sedimentation Rate (ESR) is one of the most common lab tests requested by physicians across the globe. Although it doesn’t enjoy the status of being called a diagnostic test, even then it is in continuous use as a good indicator in conditions like infections and inflammations; for screening and prognosis of certain diseases and also for monitoring the course of an existing disease. It is a good indicator to estimate the quantitative change in plasma that may occur in a lot of clinical conditions ranging from simple to much serious disorders such as inflammation, infection, pregnancy, obesity and even malignancies. In certain hematological conditions such as polycythaemia, sickle cell anaemia, leukemia, hypoproteinaemia as well as few other conditions like hyper viscosity, congestive heart failure etc. Physicians does rely on ESR as an indicator to some extent.

Current review is done to check its clinical importance, different aspects of ESR usage, methods by which it is performed and advancements in the test.

Introduction

Erythrocytes Sedimentation Rate (ESR) basically measures the speed of red cells to settle down in a vertically mounted standardized open-ended tube (length 30 cm) for one hour in autologous plasma; thus the name sedimentation rate[1]. It is an inexpensive, low-cost, low-technology and less cumbersome procedure. Since ESR fluctuation is observed in quite a large number of conditions, it is considered as a highly non-specific parameter and therefore it cannot be used as a pin-point diagnostic test for any particular disease[2].

There is another parameter very commonly ordered by the physicians; C-reactive protein (CRP), but it certainly is less cost-effective than ESR. CRP, just like ESR, is also used to assess inflammatory responses. Although ESR has certain limitations as compared to CRP in a number of inflammatory conditions such as in rheumatoid arthritis, yet it is widely considered as an indicator of acute phase reaction that indirectly measures the extent of inflammation. This is because the acute-phase plasma proteins (such as fibrinogen) cause the red cells to settle down quickly. Nonetheless ESR is a helpful predictive tool in inflammatory diseases, helps in indications of certain diseases, in monitoring the progress of specific conditions and also helps as a prognostic tool in malignancies[2].

ESR was not commonly used as a laboratory test until 1897, when a Polish physician named Edmund FaustynBiernacki devised a clear method of performing ESR and also described its clinical significance[3]. This progressive work was left incomplete due to his death at the age of 45 years. During his studies, he analyzed that ESR varies with age and sex and its sedimentation rate is fast in patients with low red blood cell count and slow in individuals who have fever[4]. A Swedish hematologist Robert Sanno Fähræus, in 1918, working on ESR after seven years of Edmund
Faustyn Biernacki’s death, attempted the same principle on pregnant and non-pregnant women to judge time difference of erythrocyte sedimentation\(^3\)\(^,\)\(^5\). His studies caused ESR to become a widely used pregnancy test for some time. In 1921 a Swedish scientist Alf VilhelmAlbertsonWestergren’s developed a new methodo perform and utilize this test while he was doing research on the patients with pulmonary tuberculosis\(^6\). This method got so much popularity that it is still in use around the globe.

**Mechanism of Erythrocyte Sedimentation**

ESR allows the red cells to settle down in autologous plasma for one hour, which basically indicates the plasma to blood cells ratio. An increased ratio (more plasma than red cells) will cause a fast sedimentation of erythrocytes, thus a high ESR will be observed and vice versa. This shows that the rate of red cell sedimentation in ESR does not only depend upon red cell count and red cell shape, but also upon the specific gravity between plasma and red cells; which can be affected by the rouleaux formation of red cells \(^3\).

There are three phases of ESR; rouleaux formation phase, decantation phase and packing of red cell.

a) Rouleaux formation phase: It is the preliminary stage that lasts approximately for 10 minutes. During this phase, red cells settle down as a stack of coins called rouleaux formation, packing them as aggregates.

b) Decantation phase (Rapid fall): This phase lasts approximately for 40 minutes. During this phase the red cells fall at a much higher and at a constant rate.

c) Packing of red cell (Slow fall): This phase also lasts for approximately 10 minutes. During this final phase the aggregated red cells pack themselves steadily at the bottom of the tube\(^7\).

**Normal Values**

ESR values, even in healthy individuals, constantly change and do not remain the same throughout the course of life. There is a progressive increase in ESR normal value with advancement in age\(^8\). Therefore, researchers formulated a method to determine normal values for all age groups in accordance with the gender. The formulae are given as under;

- Normal ESR for men = age in years / 2
- Normal ESR for women = age in years + 10 / 2 \(^9\),\(^10\)

Mean values and upper limits in 95% of normal individuals are shown in table 1.

<table>
<thead>
<tr>
<th>Age range (years)</th>
<th>ESR mean (mm/1(^{st}) hour)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Newborn</td>
<td>0-2</td>
</tr>
<tr>
<td>10-19</td>
<td>8</td>
</tr>
<tr>
<td>20-29</td>
<td>10.8</td>
</tr>
<tr>
<td>30-39</td>
<td>10.4</td>
</tr>
<tr>
<td>40-49</td>
<td>13.6</td>
</tr>
<tr>
<td>PREGNANCY</td>
<td></td>
</tr>
<tr>
<td>Early gestation</td>
<td>48 (62 if anemic)</td>
</tr>
<tr>
<td>Later gestation</td>
<td>70 (95 if anemic)</td>
</tr>
</tbody>
</table>

**Factors affecting ESR**

ESR result is sensitive to quite a few things. An increase or decrease in ESR result can be observed due to a number of factors that include;

a) Plasma elements affecting ESR
b) Red cell elements affecting ESR
c) Drugs affecting ESR
d) Conditions associated with raised ESR
**Table 2: Plasma elements affecting ESR**\(^7,11\)

<table>
<thead>
<tr>
<th>Decreased</th>
<th>Increased</th>
</tr>
</thead>
<tbody>
<tr>
<td>Increased albumin</td>
<td>Decreased albumin</td>
</tr>
<tr>
<td>Decreased fibrinogen</td>
<td>Increased fibrinogen</td>
</tr>
<tr>
<td>Hyperviscosity</td>
<td>Globulins</td>
</tr>
</tbody>
</table>

**Table 3: Red cell elements affecting ESR**\(^7,11\)

<table>
<thead>
<tr>
<th>Decreased</th>
<th>Increased</th>
</tr>
</thead>
<tbody>
<tr>
<td>Size</td>
<td>Microcytes</td>
</tr>
<tr>
<td>Quantity</td>
<td>Polycythaemia</td>
</tr>
<tr>
<td>Morphology</td>
<td>Sicke cells, spherocytes, schistocytes</td>
</tr>
<tr>
<td>Others</td>
<td>Hemolysis, hemolytic anemia</td>
</tr>
</tbody>
</table>

**Table 4: Drugs affecting ESR**\(^7,11\)

<table>
<thead>
<tr>
<th>Decreased</th>
<th>Increased</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cortisone</td>
<td>IVIG</td>
</tr>
<tr>
<td>NSAIDs</td>
<td>Heparin</td>
</tr>
<tr>
<td>Valproic acid</td>
<td>Oral contraceptives</td>
</tr>
</tbody>
</table>

**Table 5: Conditions associated with raised ESR**\(^7\)

<table>
<thead>
<tr>
<th>System</th>
<th>Conditions</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Renal</strong></td>
<td>Renal failure</td>
</tr>
<tr>
<td></td>
<td>Glomerulonephritis</td>
</tr>
<tr>
<td><strong>Rheumatological</strong></td>
<td>Acute rheumatic fever</td>
</tr>
<tr>
<td></td>
<td>Systemic lupus erythematosus</td>
</tr>
<tr>
<td></td>
<td>Sarcoidosis</td>
</tr>
<tr>
<td></td>
<td>Osteomyelitis</td>
</tr>
<tr>
<td><strong>Others</strong></td>
<td>Congestive heart failure</td>
</tr>
<tr>
<td></td>
<td>Obesity</td>
</tr>
<tr>
<td></td>
<td>Pregnancy</td>
</tr>
<tr>
<td></td>
<td>Inflammatory bowel syndrome/Coeliac disease</td>
</tr>
<tr>
<td></td>
<td>Interstitial lung disease</td>
</tr>
</tbody>
</table>
Methods of ESR Estimation

1. Westergren’s method:
It is by far the most widely used and the most well-reputed ESR estimation method. International Council for Standardization in Hematology (ICSH) established this method[12] and it is now accepted by Clinical and Laboratory Standards Institute (CLSI)[13,14,15]. The recommended apparatus is a straight glass tube, 30 cm in length and 2.55 cm in diameter[11]. The bore must be uniform to 0.05 mm throughout the length of tube. To perform this test, anticoagulated blood should be collected in 1:4 ratios, which means 1.6 ml blood and 0.4 ml anticoagulant (sodium citrate). The Westergren’s tube should be filled up to zero mark and should be placed vertically in Westergren’s rack for 1 hour. After one hour (1st hour) the column of the plasma is read to report the ESR value[1, 16, and 17].

2. Wintrobe’s method:
For this method, anticoagulated blood should be taken in EDTA (Ethylenediaminetetraacetic acid). With the help of pasture pipette the Wintrobe’s tube is filled up to “zero” mark and placed vertically in a rack for one hour. After one hour, the reading is noted at which the column of the plasma is residing[17].

3. Semiquantitative Slide Method:
ESR can also be demonstrated by putting a drop of citrated blood on a slide. The slide is placed at an angle of 45° such that the drop comes down steadily by gravity and leaves a trail behind. The slide is then allowed to dry at room temperature. It is then stained with Leishman’s stain (4-5 drops) and is left for 2 minutes. Distilled water, almost double the amount, is poured and again the slide is left for 8 minutes. The slide is then washed in running tap water and allowed to dry. Upon examining under the microscope the red cell aggregates are observed. The aggregation is reported in grades as A, B, C and D. “A” being the least aggregated while “D” has maximum aggregation. But this method certainly is not the recommended one and needs further assessment and evaluation in order to call it appropriate[18].

4. Automated method:
In this method tube is held at an angle of 18° to the vertical in the instrument which also maintains temperature. After 20 minutes, the height of red cells is measured by using light transmission. To make a comparison of this method with Westergren’s method, mathematical correction is applied. Although it’s a fast and fully automated technique, scientists are still perplexed as the results are sometimes comparable and sometimes not. Nevertheless, it is a common technique observed by labs worldwide nowadays. Much work is being done to improve this technique and continuous comparison with Westergren’s method is being applied[19].

5. Portable microfluidic system:
In 2016 Turkish scientists devised a new technology to measure ESR in accordance with erythrocytes aggregates. This method gives the ESR result in just 2 minutes via a small finger prick. According to them 40 μl whole blood is filled in a disposable polycarbonate cartridge illuminated by a near infrared emitting diode. By using a solenoid pinch valve, the erythrocytes are disaggregated under the effect of a mechanical shear force. After the aggregation is completed, a photo detector is used to measure the transmitted light coming through the cartridge for 1 min and 30 seconds. At complete disaggregation, the intensity level is at its lowest and vice versa[20].

Quality control of ESR
Routinely standardized methods can be used for quality control. Whole blood preparation can be assessed for daily control on automated system (e.g. ESR-Chex or Ves-Matic Cube 200)[21]. Daily calculation of cumulative mean of 100 specimens every day in a regular situation should be done. Less than 15% coefficient of variation is a reasonable indicator for routine instrument monitoring[22].

Discussion
ESR is in use for almost a century in clinical practice, although its specificity is still controversial. Use of
ESR basically quantifies inflammatory changes which occur during infectious, inflammatory and neoplastic disorders. Increase or decrease of certain protein production is the reflection of inflammatory or necrotic changes in the body. The change in the degree of protein occurs due to many factors such as acute and chronic infections, tumors, degenerative and autoimmune diseases such as rheumatoid arthritis[22].

The pathophysiological elevation of ESR may be due to anemia, known fibrinogen protein[7, 23], hypercholesterolemia[5], intense obesity [1, 8], pregnancy [3], old age[9,10] and malignancies and renal diseases [24]. The effect of anemia is mediated by the alteration in the ratio of erythrocytes to plasma, which favors rouleaux formation. Fibrinogen may or may not be the cause. For example, increase in ESR in certain diseases can be observed due to elevated serum level of non-fibrinogen proteins like M proteins, Macroglobulins, and RBC agglutinins, while an elevated ESR in renal failure maybe attributed to elevated serum fibrinogen levels[4,7, and 8]. On the other hand, intense obesity also demonstrates a high ESR which is most likely due to the elevated fibrinogen levels [1,8].

Above mentioned diseases and their relative ESR values clearly demonstrate that ESR is a parameter that does not depend on any single factor. This makes it quite unreliable. On the other hand, in conditions like multiple myeloma, Waldenstrum gammaglobinaemia, rheumatoid arthritis, polymyalgia rheumatica, temporal arteritis etc., the significance of ESR cannot be ruled out[5,6]. In the said conditions ESR still has diagnostic significance which is not debatable. In many other circumstances brief or persistent rise of ESR is also used to observe disease activity and response to treatment. Slight increase of ESR is usually found in acute inflammation, infection, pregnancy[4,7] and in people of advanced age[9,10], while a bit more aggressive rise is seen in conditions in which globulin protein is increased which is due to severe infection or inflammation.

Pathophysiologic decrease of ESR may be found in clinical conditions like, sickle cell anemia, polycythemia, dysfibrinogenaemia, afibrinogenaemia, high serum bile salt level and in hematological diseases which cause red cell morphological abnormalities[7]. Common morphologic changes of RBC's can hold up pellet formation which causes ESR to be affected. Abnormal or irregular shaped RBC's (e.g., sickle cells) do not settle down quickly, resulting in a decreased ESR. Spherocytes, anisocytosis, and poikilocytosis also impede with the stacking of red cell, causing the same[7,10]. A decreased ESR is not clinically important in some conditions like polycythemia and leukocytosis, while on the other hand it is quite significant in hereditary disorders such as sickle cell anaemia and hereditary spherocytosis[7].

Regarding malignancies, it is a general perception that ESR is clinically significant in hematological neoplasms only; it is equally valuable in some non-hematological malignancies as well, such as prostate cancer, ovarian cancer and breast carcinoma. An elevated ESR among these malignancies is the sign of poor prognosis and advancing disease[25].

ESR can also be used to predict coronary heart disease as well as can be used as an indicator of atherosclerosis that maybe caused due to rheumatoid arthritis[26]. ESR along with CRP and lactic acid play a vital role in monitoring the patients who are at high risk of developing cerebral infarction due to internal carotid artery occlusion[27].

Conclusion
New techniques and ways are continuously being explored to perform this test. Scientists are working hard to find the methods to use less amount of blood and get quick results. Since the comparison of new techniques is always done with Westergren’s method, looks like until something really applausable does not come up, Westergren’s method is by far the gold standard technique to perform this test.
Keeping all the aspects discussed above in mind, it can therefore be concluded that although ESR is not treated as a diagnostic or a well-reputed parameter, yet it becomes quite handy in a lot of situations. Physicians do rely on this test and get help from this parameter in a number of conditions, which makes ESR a really useful tool in diagnostic approach.

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CASE REPORT

POLYORCHIDISM PRESENTING WITH INGUINAL HERNIA: A CASE REPORT AND A REVIEW OF LITERATURE

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ABSTRACT
Triorchidism is the commonest variety of polyorchidism, an entity with more than two testes is an extremely rare congenital anomaly of the testis. Although removal of the supernumerary testis is a safer alternative proposed, recent literature recommends more conservative approach in normal testes with vigilant regular follow up to screen for malignancy. This case presented as a left inguinal swelling diagnosed as indirect left inguinal hernia with left undescended testis. Intraoperatively indirect inguinal hernia was noted with supernumerary testis at deep ring in addition to normal left testis in hernia sac in the inguinal canal. The ectopic testis was small (2×2×1 cm) lacking epididymis and with short vas deferens. After performing herniotomy and orchidopexy, supernumerary testis was excised for a possible malignancy. Histopathological examination showed presence of immature testicular tissue.

Keywords: Polyorchidism, Triorchidism, Supernumerary Testis

1. INTRODUCTION
Polyorchidism is a very rare congenital anomaly of the urogenital system and is defined as the incidence of more than two testes1. Triorchidism is its most common presentation2. The left side is mainly affected. Nearly 50% of the cases are identified between 15 and 25 years of age3. Commonly associated anomalies are testicular maldescent (40%), inguinal hernia (30%), testicular torsion (13%), hydrocele (9%), and hypospadias (1%)4. A higher tendency for malignant transformation in non-functional testis necessitates the radiological and functional assessment of polyorchid testes. We describe a case of triorchidism presenting with inguinal hernia in a ten-year-old male and briefly discuss its management.

2. CASE PRESENTATION
A ten-year-old boy was admitted with the complaint of left inguinal swelling for 3 years without associated history of trauma or pain. On physical examination, a reducible swelling in the left inguinal region with positive cough impulse and positive deep ring occlusion test was noted. The right testis was normal in size and palpated in the scrotum, whereas left testis was impalpable. So the diagnosis of left sided inguinal hernia with undescended testis was made. The family history was unremarkable. Other physical findings were normal. Ultrasound showed left testis in the inguinal canal whereas right testis in the scrotum. The patient was operated for left inguinal herniotomy. At the time of operation the left inguinal region was explored. Intraoperative findings of indirect inguinal hernia sac was present with small undescended supernumerary testis of size 2×2×1 cm at the deep inguinal ring having short vas deferens and a 2.5x2.5x1 left testis with epididymis and vas deferens in the hernia sac. (&2) Hernia sac with cord structures at the deep inguinal ring were identified. After performing high ligation and fixation of the normal testis into the scrotum, supernumerary testis was removed for a possible malignancy and anomalous anatomy. Histopathological evaluation revealed presence of immature testicular tissue. The postoperative period was uneventful.
3. DISCUSSION
Polyorchidism is the incidence of more than two testes confirmed by histology. This condition is very rare, and nearly over a hundred cases were described in the literature. Although it can remain asymptomatic, it is often related to processus vaginalis anomalies and undescended testis in childhood. Supernumerary testes may be found in abdominal, inguinal or scrotal location; they are mostly on the left side, and they are usually smaller than both contralateral and ipsilateral testes. The exact cause of polyorchidism is not clear, though accidental division of genital ridge before 8 week of gestation could be a likely cause. There are theories suggesting the likely presence of multiple testes first being duplication of longitudinal genital ridge resulting into separate testes so total volume of testis surpasses of one. The second theory describes transverse division of genital ridge at different levels resulting into different combination of testes, vas deferens and epididymis.

Thum\(^8\) proposed a functional classification of polyorchidism based on embryonic development (Table 1). According these classifications, our patient was considered as Type 1.

**Table 1.** Functional classification of polyorchidism based on embryonic development  
(table derived from Thum\(^8\)).

<table>
<thead>
<tr>
<th>Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Type I</td>
<td>The supernumerary testis lacks an epididymis and vas. The split-off part of the primordial gonad does not communicate with the mesonephric tubules from which the epididymis develops.</td>
</tr>
<tr>
<td>Type II</td>
<td>The supernumerary testis is linked to the regular testis by a common epididymis and shares a common vas with it. The division of the genital ridge occurs in the region where the primordial gonads are attached to the mesonephric ducts, although the latter are not divided.</td>
</tr>
<tr>
<td>Type III</td>
<td>The supernumerary testis has its own epididymis but shares the vas with the regular testis.</td>
</tr>
</tbody>
</table>
Polyorchidism usually presents itself in the 2nd to 3rd decade, with nearly 50% of cases reported between 15 to 25 years of age. The common presentations of polyorchidism manifests as maldevelopment (40%), hernia (30%), torsion (15%), hydrocele (9%), malignancy (6%), infertility and epididymitis. If a polyorchidism is suspected of palpable mass in the groin or scrotum, ultrasound is the effective, noninvasive investigation and preoperative assessment. On ultrasound, an accessory testis usually shows a fine granular echotexture similar to normal testis. Color Doppler ultrasound can give further information regarding blood flow pattern in the testis. MRI may provide confirmation when ultrasound is not conclusive.

The management of polyorchidism has been still controversial. In the past it was common practice to remove the supernumerary testicle with removal of the smaller mass. More recently, with advances in ultrasound and magnetic resonance imaging technology, more conservative approaches have been recommended. Generally, authors have either supported surgical exploration or follow up with imaging investigations. Biopsy is a contentious issue and not routinely performed. A conservative approach needs magnetic resonance imaging, and high resolution sonography as an effective, noninvasive technique of correctly diagnosing polyorchidism. Several authors assert that conservative management is the suitable choice. They recommend that supernumerary testis, even in ectopic locations, must be saved if they look normal and are potentially functional. They believed that the absence of any concomitant disorder and if testicular tumour can be ruled out by sonography or magnetic resonance imaging, surgical exploration with biopsy could be unnecessary. In contrast, surgical exploration has the benefit of allowing orchidopexy to prevent torsion and determining the testicular outflow tracts and estimating reproductive capacity. Indications for removal include malignant or dysplastic change on biopsy, sonographic evidence of malignancy, and absent reproductive potential of the polyorchid testis which lacks an epididymis or vas. In our case, the supernumerary testis showed no reproductive capacity due to a lack of attachment to a cord structure. It was therefore removed because of anomalous anatomy and possible malignancy.

4. Conclusion
The diagnosis of polyorchidism is typically incidental. According to our opinion, if polyorchidism is associated with doubtful concomitant pathology, surgical exploration should be performed. But, in uncomplicated polyorchidism, conservative management with magnetic resonance imaging or ultrasonography observation should be recommended.

Consent
Written and informed consent was taken from the patient's parent for publication of this case report and images.

Conflict of Interests
No conflict of interests.

References
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I would like to thank and appreciate the kind efforts of all reviewers who spared their valuable time in reviewing the articles of BJHS and giving valuable feedback. Their contributions have not only helped in the continuous growth of the journal but have also improved the quality of the articles. Following are the names of the reviewers who reviewed articles for the current issue:

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