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Cardiovascular complications and anabolic steroids

Anabolic steroids have become a popular drug among athletes and are known to have a multitude of pathological effects when administered in supraphar-macological doses. Sudden death due to right heart failure subsequent to venous thrombus formation in an athlete abusing anabolic steroids has not been previously reported. We are now reporting on the role of testosterone in coagulation and hope this will further direct attention to its probable role in the myocardial infarctions and strokes that occur in athletes using anabolic steroids.

This report involves a 26-year-old competitive bodybuilder who suffered a sudden death due to right heart failure subsequent to a bilateral pulmonary embolism from deep venous thrombus of lower extremities. The 136 kg, 182 cm, male bodybuilder of very large muscular proportions (body mass index=40·8 kg . m^{-1}) collapsed suddenly while moving furniture. The patient was transferred by paramedics to a local community hospital where he never recovered. Autopsy was performed at the Medical Examiners office and the cause of death was ruled right heart failure due to a bilateral pulmonary embolus of natural causes. At autopsy, the heart weighed 440 g with moderate left ventricular hypertrophy. Examination of the aorta revealed no significant atherosclerotic changes. The subject had a history of anabolic steroid use and had been successfully competing in bodybuilding contests for several years.

Recently, there have been a few case reports attempting to link thrombosis and anabolic steroid abuse[1,2]. The role of anabolic steroids in platelet aggregation has support in the literature. Sex differences alone have demonstrated profound differences in platelet aggregation. Male rats are 10 times more responsive to aggregating agents in females. Castration of males markedly reduces their platelet sensitivity to aggregation, whereas ovariectomy elevated the platelet sensitivity in female rats. In vitro, androgens at physiological concentrations consistently stimulate platelet aggregation[1]. Androgens and other sex steroids are known to be absorbed at platelet membranes modifying their surface properties, inducing potential and permeability changes[2]. Androgens may potentiate platelet aggregation through increased production of arachidonic acid, a precursor to the potent platelet aggregator thromboxane A2 or, in aortic smooth muscle, decreased production of prostacyclin[3]. Recently, testosterone was shown to increase thromboxane A2 receptor density and responsiveness in rat aortas and platelets[4]. In addition, it has also been reported that androgen receptors exist in the vascular tissue, on cardiac atrial and ventricular cells of primates. To date, the function of these receptors is unknown.

Myocardial infarctions, stroke and other thrombotic complications have been reported in athletes abusing anabolic steroids[5]. Therefore, with the majority of anabolic steroid cases being related to myocardial infarctions and stroke, it seems that the common denominator in all these cases is thrombus formation. The role of androgens in the complex coagulation system is far from being understood; however, this case points at the role of androgens in thrombus formation and subsequent death.

Interestingly, there is the possibility of androgen regulation of certain plasma coagulation factors. Protein S is an anticoagulant produced in hepatocytes and leydig cells of the testis. Protein S functions as a cofactor with Protein C in the inactivation of Factors Va and VIIIa. In addition, Protein S deficiency leads to a predisposition for venous thrombus[6]. A portion of Protein S is structurally homologous to the steroid binding domain of sex hormone-binding globulin (SHBG). SHBG is a steroid-binding protein that binds dihydrotestosterone, testosterone and estradiol. SHBG is positively regulated by oestrogens and negatively regulated by androgens.

Thus, with the administration of anabolic steroids, SHBG levels drop dramatically allowing more free (unbound), biologically active steroids in the system. If Protein S is regulated by sex steroids, it is plausible that Protein S levels also decrease with elevated androgen levels, thus allowing for an increase in the activity of the coagulation system and subsequent thrombus formation.

In summary, laboratory animal data have demonstrated a strong correlation between increased thrombosis and elevated testosterone levels. While extrapolation to the human population is always difficult, quite plausible mechanisms exist to establish a rationale for such a link. This case will hopefully lead to further studies on the role of androgens in thrombosis and further warn physicians and athletes about the pathological effects of anabolic steroids.

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Delayed occurrence of complete atrioventricular block after radiofrequency ablation of atrioventricular node reentrant tachycardia. Follow-up

The ability to cure atrioventricular (AV) nodal reentry with radio-