Paradoxical Increased Risk of Thrombosis after Initiation of Vitamin K Antagonists in Thromboembolic Disease

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Introduction

Vitamin K Antagonist Oral Anticoagulants (VKA) are effective in the primary and secondary prevention of venous thromboembolism, in the prevention of systemic embolism and stroke in patients with prosthetic heart valves or atrial fibrillation. In patients with thromboembolic disease Low Molecular Weight Heparin (LMWH) and oral VKA are started at diagnosis. LMWH is than stopped once the International Normalised Ratio (INR) values are in the therapeutic range. The timing of stopping LMWH is important since its discontinuation too soon after a therapeutic INR has been achieved may paradoxically increase the risk of thrombosis. In a recent study, only 20% of the patients met the currently recommended treatment guideline of 4 days or more of heparin and warfarin overlap, until the international normalized ratio is greater than 2.0 for 2 consecutive days [1]. The manuscript will discuss the mechanisms behind the increased risk of thrombosis after initiation of oral anticoagulation therapy and how to avoid these risks.

Vitamin K Dependent Proteins

Hepatic synthesis of vitamin K-dependent factors and proteins involves gamma-carboxylation of precursors of these substances. A specific carboxylase enzyme converts glutamic acid residues found in the NH2-terminal region of these precursors to form γ-carboxyglutamic acid [2]. This reaction requires vitamin KH2 (hydroquinone), a reduced form of vitamin K. Vitamin KH1 is than oxidised to vitamin KH2 via vitamin K1 reductase [3]. Protein S is a vitamin K-dependent glycoprotein, which serves as an anticoagulant protein (proteins C and S) is limited, resulting in reduced activity of factor II, is depleted much sooner than factors IX and X [6]. Initial changes in the prothrombin time indicate initial depletion of factor VII and do not provide protection against thrombosis [7]. The antithrombotic effect of warfarin, caused primarily by a reduction in the activity of factor II, is delayed for as long as 72 to 96 hours [8].

Adequate anticoagulation with warfarin requires selective suppression of factors II and X. In vitro studies have shown that the rate of prothrombin activation is linearly related to the concentration of factor II [9]. In vivo, prothrombin activation can be monitored by measuring the levels of prothrombin fragment 1.2 (F1+2) [10]. A significant reduction in F1+2 takes 88 and 120 hours after the initiation of anticoagulant treatment in patients and in healthy volunteers, respectively [11]. In another study, factor II and F1+2 levels were observed to be high in the initial phase of oral anticoagulant therapy despite achieving therapeutic INR [12].

Haemostatic Balance

The aim of the VKA anticoagulation therapy is to reduce the formation of thrombin by interfering with the vitamin K-dependent coagulation factors. Warfarin does this by decreasing the vitamin K-dependent procoagulant factors but it also inhibits coagulation inhibitors, proteins C and S. Therefore the net effect of warfarin depends on the haemostatic balance between the procoagulant factors and the inhibitors of coagulation.

The half-life of factor VII is 6 hours, whilst the half-lives of factors II, IX and X are 72 to 96 hours. This means that factor VII is depleted much sooner than factors II, IX and X [6]. Initial changes in the prothrombin time indicate initial depletion of factor VII and do not provide protection against thrombosis [7]. The antithrombotic effect of warfarin, caused primarily by a reduction in the activity of factor II, is delayed for as long as 72 to 96 hours [8].

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Oral anticoagulation, liver disease, and disseminated intravascular coagulation (DIC) cause deficiencies of protein C and S and systemic lupus erythematosus, nephrotic syndrome, pregnancy and certain hormones cause deficiency of protein S. Protein C, once activated, functions as a physiologic anticoagulant by proteolytically degrading activated factors V and VIII [13]. Homozygous protein C deficiency is associated with extensive thrombotic disease and death in infancy [14]. Patients with partial protein C deficiency also experience recurrent thrombotic episodes [15]. The heterozygotes are at increased risk of warfarin-induced skin necrosis, a condition caused by diffuse thrombosis of small venules [16]. Protein C is rapidly reduced to a low level following warfarin administration [17]. This may occur prior to adequate suppression of factors II and X [18]. There is therefore a prothrombotic phase early on after initiation of warfarin therapy. Protein S is a vitamin K-dependent glycoprotein, which serves as an activated protein C binding protein that is essential for assembly of the anticoagulant complex on cell surfaces [19]. Protein S functional levels are often low in patients with an acute thrombosis and its activity is reduced further after initiation of warfarin therapy. The levels decline more slowly than protein C, reaching a nadir at 46 hours [12]. In a study of 51 patients stabilised on warfarin, total protein S was reduced to 64.6 ± 16.4% compared with a level in healthy subjects of 114.7 ± 21.7% [20]. Low levels of protein S are associated with thrombosis [21]. Since patients with protein C levels of less than 65% are at risk of thrombosis, an early decline of proteins C and S, preceding the fall of...
the vitamin K dependent procoagulants results in a prothrombotic state [22]. The antithrombotic effect can be achieved only after the vitamin K-dependent procoagulants reach levels of about 25% [23]. Such antithrombotic levels cannot be achieved during the first days of treatment with warfarin. In vivo prothrombin activation is a function of the balance between factor II and protein C concentrations and thrombosis is not prevented until nadir concentrations of factor II are obtained, which can take 40–192 hours. During this time patients are paradoxically at increased risk of thromboembolic disease. It is therefore important to overlap heparin and warfarin treatment for at least 48 hours after therapeutic INR values have been achieved. This will cover the period of hypercoagulability until protein C rises again to sufficient levels to regulate factors Va and VIIIa.

Conclusions
During commencement of oral VKA therapy a there is a transient hypercoagulable state when the patients are at high risk of further thromboembolic disease. This is due to the difference in plasma half-lives between the vitamin K-dependent pro-coagulation factors II and X, and the vitamin K-dependent anti-coagulant proteins C and S. The antithrombotic effect of warfarin, caused primarily by a reduction in the activity of factor II, is delayed for as long as 72 to 96 hours. Protein C has a half-life of 6 hours and decreases at the same rate as factor VII in the first three days of therapy. Higher doses of warfarin initially may rapidly deplete protein C prior to adequate suppression of factors II and X. Similarly protein S activity is markedly reduced after initiation of warfarin therapy, reaching a nadir at 46 hours. During this phase of treatment, low levels of proteins C and S in association with inadequate suppression of factors II and X incurs a high risk of thrombosis. There is therefore a prothrombotic phase early on after initiation of warfarin therapy. It is therefore important to overlap heparin and warfarin treatment for at least 48 hours after therapeutic INR values have been achieved to cover the period of hypercoagulability until a balance in favour of antithrombotic effects of warfarin is achieved.

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