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Hormone therapy and haemostasis among postmenopausal women

A review

Running title: Hormones and haemostasis in menopausal women

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Abstract

Objective. Postmenopausal hormone therapy (MHT) which consists of exogenous estrogens with or without combined progestogens remains the most effective treatment to correct climacteric symptoms. Depending on its characteristics, it may nevertheless increase the risk of venous thromboembolism and its effect on haemostasis has been studied for several decades. The aim of this review was to summarize the current knowledge on the effect of MHT on haemostasis, taking into account the route of estrogen administration, the estrogens daily doses and chemical structures as well as the pharmacological classes of progestogens.

Methods. We selected data from randomized controlled trials which included a control group (either placebo or no treatment) and we conducted our analysis on different biomarkers generations.

Results. Overall, studies showed a haemostasis imbalance among oral estrogens users with a decrease in coagulation inhibitors and an increase in markers of activation coagulation leading to a global enhanced thrombin generation. By contrast, transdermal estrogens use was associated with less change in

haemostasis variables and did not activate coagulation and fibrinolysis. No clear difference in MHT effect on haemostasis was highlighted between estrogens daily doses and compounds as well as between pharmacological classes of progestogens

Conclusions. Changes in haemostasis are in accordance with clinical results that show an increased thrombotic risk with oral but not transdermal estrogens use.

Key words. Postmenopausal hormone therapy, haemostasis, randomized controlled trials, estrogens, progestogens.

Introduction

Women are subject to steroid sex hormones exposure from puberty to menopause and other times if prescribed postmenopausal hormone therapy (MHT). This treatment remains the most effective treatment of climacteric symptoms ¹ but may increase the risk of venous thromboembolism (VTE) ^{2, 3}. Nevertheless, there is now compelling evidence that thrombotic MHT effect may strongly depend on the route of estrogen administration ⁴⁻⁹, the estrogens daily doses ⁸ and chemical structure ^{10, 11} as well as the pharmacological class of progestogens ^{5, 7, 9}.

The MHT effects on haemostasis have been studied for several decades with a dual interest. On one hand, investigating the coagulation balance or imbalance among MHT users provides a biological support to the thrombogenic potential of specific treatments ¹²⁻¹⁵. On the other hand, some haemostatic variables have been validated as surrogate marker markers of VTE ¹⁶⁻¹⁸ and can be used to investigate the pharmacologic effect of MHT on thrombosis ¹⁹. During the early 80', factors and inhibitors of coagulation and fibrinolysis were the only haemostatic variables that have been investigated in response to MHT use. Few years later, activation markers have been found to be helpful as markers of coagulation and/or fibrinolysis. More recently, some global assays used to test a hypercoagulability state have been validated as surrogate markers of VTE risk.

Using exclusively the data from randomized trials that included a control arm (either placebo or no treatment), we propose here to summarize the results of MHT and haemostasis, taking into account the route of estrogen administration, the estrogens daily doses and chemical structure as well as the pharmacological class of progestogens ^{12, 13, 20-49}.

Haemostasis and thrombosis biomarkers

Haemostasis is a physiological state that includes both coagulation and fibrinolysis (figure 1). Together with the platelets, the haemostatic system maintains blood in a fluid state under normal conditions and can activate controlled mechanisms to prevent blood loss^{50, 51}.

Coagulation cascade is a set of initiation and amplification processes that lead in its final phase to the fibrin clot after the conversion of fibrinogen by the thrombin, the key enzyme of the system. After activation of several coagulation factors, both intrinsic and extrinsic pathways conduct to activated factor X that is responsible, together with activated factor V, for thrombin generation after a proteolytical cleavage of prothrombin and releasing of prothrombin fragment 1+2. Accretion of fibrin depends on both activity of the coagulation cascade and fibrinolysis which causes degradation of fibrin. Plasminogen, the central protein of the fibrinolytic system, is converted into plasmin which cleaves fibrin clot into D-Dimers, soluble degradation products⁵²⁻⁵⁴.

For decades, several generations of biomarkers have been used to investigate the thrombotic process (table 1). During the early years, factors and inhibitors of both coagulation and fibrinolysis were investigated with clear direct relationship neither with an activation of coagulation and fibrinolysis nor with the clinical risk of VTE^{4, 55}. Then, specific activation markers of coagulation and fibrinolysis have been identified and were used to highlight the initiation of a physiological process that conducts to the fibrin clot formation and degradation. Nevertheless, this second generation of biomarkers has not been consistently related to VTE risk¹⁹. More recently, global tests of a hypercoagulability state have been validated as surrogate markers of VTE¹⁶⁻¹⁸ and can be used for both investigating the pharmacological effect of MHT and as a plausible biological reason for the potential thrombogenic role of MHT. This global test of thrombin generation is an *in vitro* assay of the ability for a plasma sample to generate thrombin following a coagulation activation. This thrombin generation reflects therefore all the integrated pro and anticoagulant reactions that can be implicated and can regulate the formation and inhibition of thrombin⁵⁶.

Characteristics of postmenopausal hormone therapy

Postmenopausal MHT has been introduced in the early 50' for counteracting climacteric symptoms including hot flushes, vaginal dryness and depression. It is also efficient to prevent osteoporosis. MHT initially consisted of an estrogenic compound administered alone but, in the 70', progestogens were added to estrogens to reduce the increased risk of endometrial hyperplasia and cancer associated with estrogen therapy⁵⁷.

There are now several types of MHT that differ according to the chemical structure, the daily doses and the route of administration. The characteristics of the main marketed MHT are summarized in the figure 2.

The estrogenic compound of estrogen therapy (ET) consists of either 17 β -estradiol, the bio-identical compound, or synthetic ones including estradiol valerate and conjugated equine estrogens (CEE). The natural 17 β -estradiol can be administered orally and non-orally. Non oral 17 β -estradiol can be given transdermally but rarely nasally^{4, 58}. Estradiol valerate is a synthetic compound administered by oral route, the composition of which and therefore the effects are very close to those of 17 β -estradiol^{59, 60}. Finally, CEE is synthesized from urine of gravid mares and contains more than 10 known biologically active estrogen compounds including mainly estrone sulfate and equilin sulfate. It is always orally administered¹⁰.

Progestogens compound of estrogen/progestogen therapy (EPT) include both progesterone, the bio-identical compound synthesized and secreted by ovary, and synthetic ones named progestins which derived from either progesterone (pregnanes and 19-norpregnanes) or testosterone (19-nortestosterone). Pregnane derivatives consist of different molecules including dydrogesterone, medrogestone, chlormadinone acetate, cyproterone acetate and medroxyprogesterone acetate (MPA). Norpregnane derivatives include nomegestrol acetate, promegestone, trimegestone and nesterone. Finally, nortestosterone derivatives consist of ethinylated derivatives, non ethinylated derivatives, spironolactone derivatives and tibolone. Nortestosterone ethinylated derivatives are composed of estranes, including especially norethisterone acetate (NETA) and of gonanes which are preferentially used in contraceptive pills. Nortestosterone non ethinylated derivative (dienogest) and the spironolactone

derivative (drospirenone) are also used in contraception. As an EPT compound, progestogens are always combined with estrogens and almost exclusively administered by oral route⁵⁷.

According to the countries, medical practices regarding postmenopausal MHT use may present important differences in term of chemical structure and route of administration. In France, women are preferentially prescribed 17 β -estradiol transdermally administered and combined with micronized progesterone. By contrast, oral CEE combined with MPA are often used in USA.

Estrogens-induced changes in haemostasis

MHT that consists of exogenous estrogens with or without combined progestogens has long been believed to have little effect on VTE risk. However, it is known for several decades to induce changes in haemostasis. Nevertheless, these modifications in coagulation and fibrinolysis may depend on several MHT characteristics, including especially the route of estrogens administration (table 2).

Route of estrogen administration

Within the twenty-eight selected randomized controlled trials of MHT and haemostasis which included a control group (either placebo or no treatment), a large majority investigated only the effect of oral estrogens^{20-24, 26-32, 34-36, 39, 42, 43, 45, 46, 48, 49}. Some of them included both oral and transdermal arms^{12, 13, 37, 38, 44} and only five trials had a transdermal but not an oral group^{25, 33, 40, 41, 47}.

Oral estrogens

Overall, there is no clear effect of oral estrogens on coagulation factors, including fibrinogen, factor VII, factor VIII, thrombin and prothrombin. Until the end of the 90', all the studies but one²² found no change in these parameters among oral estrogens users as compared to non-users or to users of placebo^{12, 20, 23, 27}. From 2001, several studies showed that some of these parameters, especially fibrinogen, factors VII and VIII decreased in oral groups without a clear biological explanation for this reduction^{28, 29, 31, 34, 37-39, 43, 45, 46}. This time-dependent discrepancy between early and recent studies may be in part explained by lack of standardization in laboratory methods that lead to important differences in biological assays. With respect to inhibitors of coagulation, most of the studies reported a significant decrease in anti-thrombin and/or protein C and protein S among users of oral estrogens, suggesting a haemostatic imbalance due to these treatments^{12, 13, 21, 27, 29, 31, 35, 37-39, 43}.

Evidence for an effect of oral estrogens on fibrinolysis factors emerged neither for plasminogen nor for tissue plasminogen activator with studies showing no change and others an increase or a decrease in one or both factors^{12, 20, 23, 27, 29}.

32, 35-38, 45, 46. By contrast, plasminogen activator inhibitor 1, as a fibrinolysis inhibitor, has been consistently found to decrease with use of oral estrogens that may thus promote a fibrinolytic process in response to the initial coagulation activation^{12, 26, 27, 29, 32, 35-39, 45, 46}.

Overall, these results on factors and inhibitors of coagulation and fibrinolysis in users of oral estrogens are consistent with studies that found on the whole an increase in activation markers of coagulation and therefore “in response” fibrinolysis, as shown by changes in prothrombin fragment 1+2 and D-dimers concentrations^{12, 13, 21, 26, 27, 31, 35, 37, 38}.

Since 2001, several studies used haemostatic global tests, including baseline thrombin generation and thrombin generation with or without activated protein C, to evaluate the effect of MHT on a hypercoagulability state^{13, 28-30, 34, 37, 38, 43, 48, 49}.

Most of the studies found an important and significant increase in APC resistance or baseline thrombin generation associated with oral estrogens use^{13, 30, 34, 37, 38, 48, 49}. Nevertheless, the biological mechanism for such APC resistance in postmenopausal women using oral estrogens remains largely not understood. Some studies have found that changes in levels of protein S and Tissue Factor Pathway Inhibitor might have important roles in determining APC resistance in women receiving oral estrogens^{15, 61}. Others reported that soluble form of endothelial protein C receptor which has been reported to inhibit APC anticoagulant activity might therefore be a candidate to explain APC resistance⁶². The three studies which showed no APC resistance with oral estrogens^{28, 29, 43} used a biological method which has been demonstrated to be sensitive to Factor V Leiden mutation but not to exogenous estrogens¹³.

Important is to remark that these results concern estrogens alone or administered in combination with a progestogen. Since women who prescribe ET have to be hysterectomized and account in industrialized countries for less than 20% of HT users, only some studies included an unopposed arm to evidence the main effect of estrogens, irrespective of progestogens^{21, 27, 29, 32, 34, 37, 38, 44-46}. Nevertheless, restricted analysis to ET led to similar results.

Taken together, these results show that oral estrogens cause a haemostatic imbalance that leads to a blood coagulation activation and a hypercoagulability state. This biological process is consistent with clinical studies that found an increase thrombotic risk among users of oral estrogens⁶³.

Transdermal estrogens

Effect of transdermal estrogens use on haemostasis has been assessed for the first time in a randomized controlled trial in 1997¹².

Inconsistency remains in the results regarding coagulation factors with studies having shown no change in transdermal estrogens users^{12, 25, 33, 47} and others which found a decrease in fibrinogen⁴¹, factor VII^{38, 41} or factor VIII^{38, 40, 41}. Similarly, while inhibitors of coagulation have been found to decrease in four randomized controlled trials^{13, 25, 37, 41}, there was no change in other investigations^{12, 47}.

Results were more coherent regarding factors and inhibitors of fibrinolysis where all studies but one⁴¹ found no change in these parameters between users of transdermal estrogens and non-users or users of placebo^{12, 25, 33, 37, 40, 47}.

In the same way, most of the studies showed no effect of transdermal estrogens on markers of coagulation and fibrinolysis^{12, 13, 25, 33, 38, 40} and this maintenance of a haemostasis balance was confirmed in studies by Oger et al. and Post et al., who both found no APC resistance in transdermal estrogens users as compared to placebo users^{13, 37}.

Altogether, results consistently showed that transdermal estrogens have little or no effect on haemostasis. Also in this case, this biological effect is consistent with results of clinical studies that found a similar thrombotic risk between users of transdermal estrogens and MHT non-users⁶³.

Oral versus transdermal estrogens

Only three studies included together oral and transdermal estrogens arms to directly compare the effect of the route of administration^{12, 13, 37, 38}. In the IMEP trial, Scarabin et al. reported a significant increase in prothrombin fragment 1+2 with oral estrogens use as compared to transdermal estrogens use¹² and few years later, Oger et al. confirmed this result in the SARAH trial¹³. In addition, this latest study, taken together with the investigation by Post, showed that the increase in APC resistance with oral estrogens use was significant when compared to transdermal estrogens use^{13, 37}. One more time, biological and clinical results are consistent⁶³.

Chemical structures

Oral 17 β -estradiol and oral CEE were included together and then compared only in one randomized controlled trial but statistical analysis did not allow comparing their respective effect on haemostasis⁴². Nevertheless, an indirect comparison of several other selected studies suggests no difference in MHT effect on haemostasis between 17 β -estradiol, estradiol valerate and CEE. Since transdermal administration exclusively concerns 17 β -estradiol, no potential effect of chemical structure can be assessed for transdermal estrogens.

Daily dose

Studies having investigated different doses of a same estrogenic compound are scarce and only concern oral route of administration^{21, 23, 32, 48}. In his study, Caine et al. found a dose effect of oral estrogens that remained borderline for prothrombin fragment 1+2 and fibrinopeptid A but reached the significance for antithrombin, protein S and protein C²¹. Few years later, Conard et al. found no effect of oral estrogens whatever the daily doses²³ and Lobo et al. who investigated three doses of CEE with or without MPA did not highlight a significant dose effect of oral estrogens on haemostasis³². Recently, Rousseau et al. found no significant difference between two daily doses of oral 17 β -estradiol⁴⁸.

Overall, there is no clear evidence for a significant dose effect of oral estrogens on haemostatic variables.

Effect of progestogens on haemostasis

Progestogens that consist of several compounds with different pharmacological properties⁶⁴ are systematically added to estrogens for women with an intact uterus to reduce the increased risk of endometrial hyperplasia and cancer associated with ET⁵⁷.

Chemical structures

Randomized controlled trials able to assess the main effect of a progestogen or to compare different progestogens are scarce and only concern progestogens combined with oral estrogens^{22, 27, 32, 34, 37, 38}.

In the PEPI trial, MPA was administered either sequentially or continuously and these two hormone regimens can be compared to micronized progesterone or to no progestogen²². Results showed similar changes in fibrinogen across the different active groups with neither an effect of adding a progestogen nor a specific effect of different chemical structures²². Few years later, Lobo conducted a large trial with different doses of CEE alone or combined with MPA³² and did not highlight any evidence for a specific effect of MPA on haemostatic parameters³². During the same time, Van Baal and Post investigated the impact of dydrogesterone and trimegestone, a pregnane and a norpregnane derivative, respectively^{27, 34}. Here too, they found no difference in their effect on haemostasis and pooled the two groups receiving opposed oral estrogens for some specific analyses^{27, 34}. In another study, the main effect of gestodene, a testosterone derivative, was assessed by comparing changes in haemostatic parameters between two arms consisting of oral estrogens either alone or combined with this progestin^{37, 38}. This study was the only one that found a decrease in Protein C in opposed oral estrogens group but not in the estrogens alone group^{37, 38}.

Overall, randomized controlled trials did not consistently detect any specific effect of progestogen on haemostasis among postmenopausal women using oral estrogens. Nevertheless, this absence of association does not necessarily imply that progestogens have no effect. It could be partly explained by a lack of statistical power and/or a dilution effect due to the concomitant use of oral estrogens that activate blood coagulation by themselves and might then hide the

specific effect of progestogens. By the way, a cross-sectional study on postmenopausal EPT and haemostasis suggested that norpregnane derivatives and micronized progesterone could have a differential effect on APC resistance and blood coagulation activation when combined with transdermal estrogens¹⁵. In addition, clinical data support a differential effect of pharmacological classes of progestogens on thrombotic risk^{5, 7}. Further data on the biological and clinical effect of progestogens are therefore needed, especially in the context of transdermal estrogens use.

Daily dose

Only two randomized controlled trials assessed the differential effects of two progestogen doses and both concerned oral estrogens use^{23, 32}. On the one hand, Conard et al. found no difference in progestogen effect on haemostasis between the two doses of nomegestrol acetate but did not find any more an effect of oral estrogens²³. We can therefore wonder about the compliance of the participants and/or the validity of biological assays. In the other hand, use of opposed CEE led to similar 13-month changes in haemostasis irrespective of the dose of combined MPA³².

Conclusion

This review is a summary of randomized controlled including a control group and having investigated the effect of postmenopausal MHT on haemostasis. This comprehensive analysis was conducted taking into account the route of estrogen administration, the estrogens daily dose and chemical structure, as well as, the progestogens. There is compelling evidence for a differential effect of estrogens according to the route of administration with a blood coagulation activation and a hypercoagulability state among oral estrogens users and a definite haemostatic balance for transdermal estrogens users. This difference would depend on neither the estrogenic compound nor the daily dose. Clinical results showing an increased VTE risk among oral but not transdermal estrogens users are absolutely consistent with these biological results. By contrast, while some clinical studies suggested that progestogens could be another important determinant of thrombotic risk, no clear effect of the different progestogens on haemostasis was highlighted.

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Table 1. Haemostatic variables

	Coagulation	Fibrinolysis
Factors	Prothrombin (ProT) Thrombin (T) Fibrinogen (Fg) Factor VII Factor VIII	Plasminogen (Plg) Tissu Plasminogen Activator (t-PA)
Inhibitors	Protein C (PC) Protein S (PS) Antithrombin (AT)	Plasminogen Activator Inhibitor 1 (PAI-1) Anti-plasmin (AP)
Activation Markers	Fragment 1+2 (F1+2) Thrombin-Antithrombin complex (T-AT) Fibrinopeptide A (FpA) Fibrinopeptide B (FpB) Ddimers (DD)	Ddimers (DD) Plasmin-Antiplasmin (P-AP)
Global tests	Baseline Thrombin generation (TG) Thrombin generation with and without activated protein C (rPCA)	

Table 2. Effect of hormone therapy on haemostatic variables among postmenopausal women in randomized controlled trials

Author, year	Follow-up	Treatment, daily dose	Number of subjects	Coagulation		Fibrinolysis		Activation markers		Global tests
				Factors	Inhibitors	Factors	Inhibitors	Coagulation	Fibrinolysis	
Notelovitz, 1983 ²⁰	18 mth	No treatment	18	Fg: no diff	AT: no diff	Plg: no diff				
		O CEE 0.625 mg + MPA 10 mg	20							
		O CEE 1.25 mg + MPA 10 mg								
Caine, 1992 ²¹	3 mth (cross-over)	Placebo	29		PC: increase in CEE 1.25 mg PS: decrease in O gps AT: decrease in O gps			F1+2: increase in O gps FpA: increase in O gps		
		O CEE 0.625 mg O CEE 1.25 mg								
Conard, 1995 ²³	3 mth	Placebo	19	Fg: no diff	PC: no diff PS: no diff AT: no diff	Plg: increase in O gps			F1+2: no diff	
		O 17βE2 1 mg + NOMAC 2.5 mg	19							
		O 17βE2 1.5 mg + NOMAC 3.75 mg	19							
PEPI group, 1995 ²²	36 mth	Placebo	174	Fg: increase in placebo gp						
		O CEE 0.625 mg	175							
		O CEE 0.625 mg + MPA 2.5 mg*	174							
		O CEE 0.625 mg + MPA 2.5 mg	174							
		O CEE 0.625 mg + prog 200 mg	178							
Scarabin, 1997 ¹²	6 mth	No treatment	14	Fg: no diff	PC: no diff	Plg: no diff	PAI-1: decrease in O gp	DD: no diff	DD: no diff	
		T 17βE2 50 μg + prog 200 mg	14	fVII: no diff	AT: decrease in O gp	t-PA: decrease in O gp				
		O 17βE2 2 mg + prog 200 mg	15	fVIII: no diff						
Nozaki, 1999 ²⁴	6 mth	Placebo	47							
		O CEE 0.625 mg	39							
		O CEE 0.625 mg + MPA 2.5 mg	48							

No comparison of changes in haemostatic variables between treatment groups

Van Baal, 2000 ²⁷ and Post, 2002 ³⁴	3 mth	Placebo	16	fVII: no diff fVIII: no diff	PC: decrease in O gps PS: decrease in O gps AT: decrease in O gps	Plg: increase in E2-only gp	PAI-1: decrease in O gps	T-AT: no diff F1+2: increase in O gps	P-AP: no diff	APCr: increase in O gps
		O 17βE2 2 mg	16							
		O 17βE2 2 mg + dydro 10 mg	14							
		O 17βE2 2 mg + trime 0.5 mg	14							
Hoibraaten, 2000 ²⁵	12 mth	No treatment	58	Fg: no diff fVII: no diff	PC: decrease in T gp PS: decrease in T gp AT: decrease in T gp	t-PA: no diff	PAI-1: decrease in T gp	F1+2: no diff T-AT: no diff DD: no diff	DD: no diff	
		T 17βE2 50 μg + MPA 5 mg	60							
Teede, 2000 ²⁶	1.5 mth	Placebo	20				PAI-1: decrease in O gp	F1+2: increase in O gp	DD: increase in O gp	
		O 17βE2 2 mg + NETA 1 mg	22			DD: increase in O gp				
Gottsater, 2001 ²⁹	3 mth	Placebo	24	fVII: no diff fVIII: no diff Fg: decrease in O gp	PC: no diff PS: decrease in O gp AT: decrease in O gp	t-PA: no diff	PAI-1: decrease in O gp	F1+2: no diff		APCr: no diff
		O E2V 2 mg	27							
Hoibraaten, 2001 and 2001 ^{30, 31}	24 mth	Placebo	69	Fg: no diff fVII: decrease in O gp	PC: decrease in O gp PS: no diff AT: decrease in O gp			F1+2: no diff T-AT: no diff DD: increase in O gp	DD: increase in O gp	APCr: increase in O gp
		O 17βE2 2 mg + NETA 1 mg	71							

Lobo, 2001 ³²	12 mth	Placebo	94	PC: no diff AT: no diff	PIg: increase in all O gps	PAI-1: decrease in O gps except in CEE 0.3 mg		
		O CEE 0.625 mg	97					
		O CEE 0.625 mg + MPA 2.5 mg	86					
		O CEE 0.45 mg	95					
		O CEE 0.45 mg + MPA 2.5 mg	96					
		O CEE 0.45 mg + MPA 1.5 mg	94					
		O CEE 0.3 mg	89					
		O CEE 0.3 mg + MPA 1.5 mg	98					
Perera, 2001 ³³	6 mth	Placebo	21	Fg: no diff	t-PA: no diff	DD: no diff	DD: no diff	
		T 17βE2 80 μg + NETA 1 mg	22					
Demirrol, 2001 ²⁸	6 mth	Placebo	55	Fg: decrease in O gp	AT: increase in O gp			APCr: decrease in O gp
		O CEE 0.625 mg + MPA 5 mg	55					
Salobir, 2002 ³⁵	6 mth	Placebo	30	PC: decrease in O gp	t-PA: decrease in O gp	PAI-1: decrease in O gp	DD: increase in O gp	DD: increase in O gp
		O 17βE2 2 mg + NETA 1 mg	31					
Oger, 2003 ¹³	6 mth	Placebo	65	PS: decrease in O and T gps			F1+2: increase in O gp	APCr: increase in O gp
		O 17βE2 1 mg + prog 100 mg	63					
		T 17βE2 50 μg + prog 100 mg	68					

Madsen, 2003 ³⁶	5 yr	Placebo O 17βE2 2 mg + NETA 1 mg	126 122			t-PA: decrease in O gp	PAI-1: decrease in O gp		
Post, 2003 and 2003 ^{37, 38}	13 mth	Placebo T 17βE2 50 μg O 17βE2 1 mg O 17βE2 1 mg + gesto 25 μg	49 33 37 33	Fg: no diff ProT: no diff fVII: decrease in all active gps	PC: decreased in O + gesto gp PS: decrease in all active gps	t-PA: decrease in O gp	PAI-1: decrease in O gps	F1+2: no diff T-AT: no diff DD: Increase in O gps	DD: increase in O gps P-AP: no diff APCr: increase in O gps
Stevenson, 2004 ⁴⁰	6 mth	Placebo T 17βE2 50 μg + NETA 125 μg	27 28	Fg: no diff fVII: decrease in T gp fVIII: no diff			PAI-1: no diff	F1+2: decrease in placebo gp DD: no diff	DD: no diff
Borgfeldt, 2004 ³⁹	12 mth	Placebo O17βE2 1 mg + NETA 250 μg O 17βE2 1 mg + NETA 500 μg	40 40 40	fVII: decrease in O gps	AT: decrease in O gps		PAI-1: decrease in O gps		
Martinez, 2005 ⁴¹	3 mth	No treatment T 17βE2 50 μg	29 30	Fg: decrease in T gp fVII: decrease in T group	PC: no diff PS: no diff AT: decrease in T gp	PIg: no diff t-PA: increase in T gp	PAI-1: increase in T gp		
Osmanagaoglu, 2005 ⁴²	6 mth	No treatment Tibolone 2.5 mg O 17βE2 2 mg + NETA 1 mg O CEE 0.625 mg + MPA 2.5 mg	88 90 84 90						No comparison of changes in haemostatic variables between treatment groups

Collins, 2006 ⁴³	6 mth	Placebo	51	Fg: no diff	AT: decrease		F1+2: no diff	DD: no diff	APCr: no diff
		O 17βE2 1 mg + NETA 0.5 mg	49	fVII: decrease	in O gps		DD: no diff		
Zegura, 2006 ⁴⁴	6 mth	Placebo	30						
		O 17βE2 2 mg	20						
		O 17βE2 2 mg + NETA 1 mg	31						
		T 17βE2 50 μg	21						
No comparison of changes in haemostatic variables between treatment groups									
Kooperberg, 2007 ⁴⁵ ; Rossouw, 2008 ⁴⁶ ; Rossouw, 2012 ⁴⁹	12 mth	Placebo		Fg: decrease			PAI-1:	F1+2: no diff	P-AP:
		O CEE 0.625 mg	**	in active gps			decrease in	DD : no diff	increase in
		Placebo		fVII: no diff			active gps		active gps
		O CEE 0.625 mg + MPA 2.5 mg		fVIII: no diff				DD : no diff	APCr: increase
Perrone, 2009 ⁴⁷	12 mth	Placebo	19	Fg: no diff	AT: no diff	Plg: no diff			
		T 17βE2 50 μg + MPA 10 mg	20	fVII: no diff					
		Tibolone 2,5 mg	21						
Rousseau, 2010 ⁴⁸	2 mth	Placebo	22	ProT: no diff					TG: increase
		O 17βE2 1 mg+ dydro 10 mg	24	fVII: no diff					in O gps
		O 17βE2 2 mg + dydro 10 mg	26	fVIII: no diff					

O: oral route of estrogen administration

T: transdermal route of estrogen administration

diff: difference

CEE: Conjugated Equine Estrogens

17βE2: 17β-estradiol

E2V: estradiol valerate

MPA: medroxyprogesterone acetate

NOMAC: nomegestrol acetate

* cyclic ** number of subjects par group depends on the nested case/control study

Prog: micronised progesterone

Dydro: dydrogesterone

Trime: trimegestone

NETA: norethisterone acetate

Gesto: gestodene

gp: group

mth: month

yr: year

Fg: fibrinogen

fVII: facteur VII

fVIII: facteur VIII

ProT: prothrombin

PC: protein C

PS: protein S

FpA: fibrinopeptid A

T-AT: thrombin-antithombin

AT: antithrombin

Plg: plasminogen

t-PA: tissu plasminogen activator

PAI-1: plasminogen activator inhibitor

F1+2: prothombin fragment 1+2

DD: D-dimers

P-AP: plasmin-antiplasmin

APCr: Activated Protein C resistance

TG: thombin generation

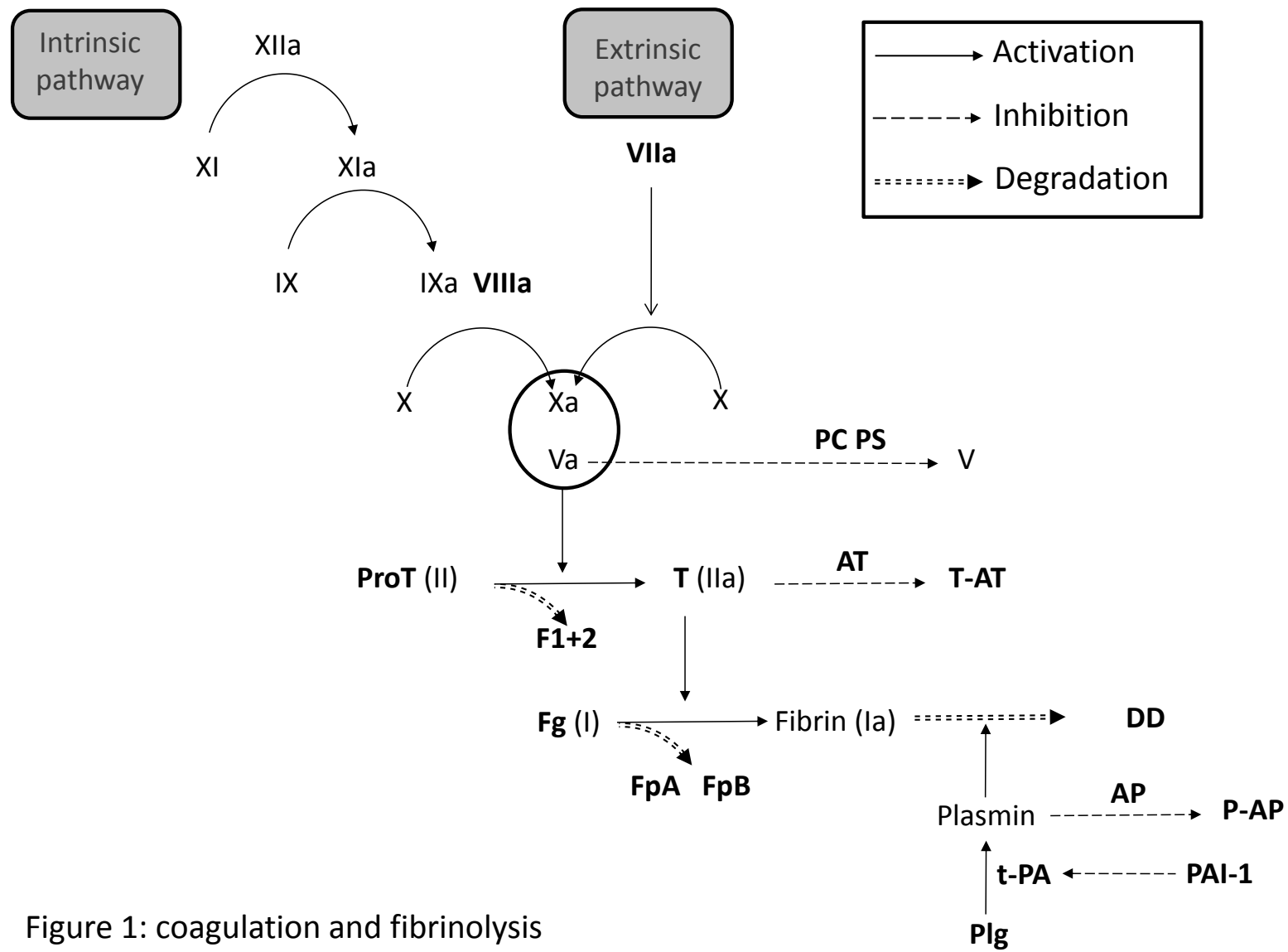


Figure 1: coagulation and fibrinolysis

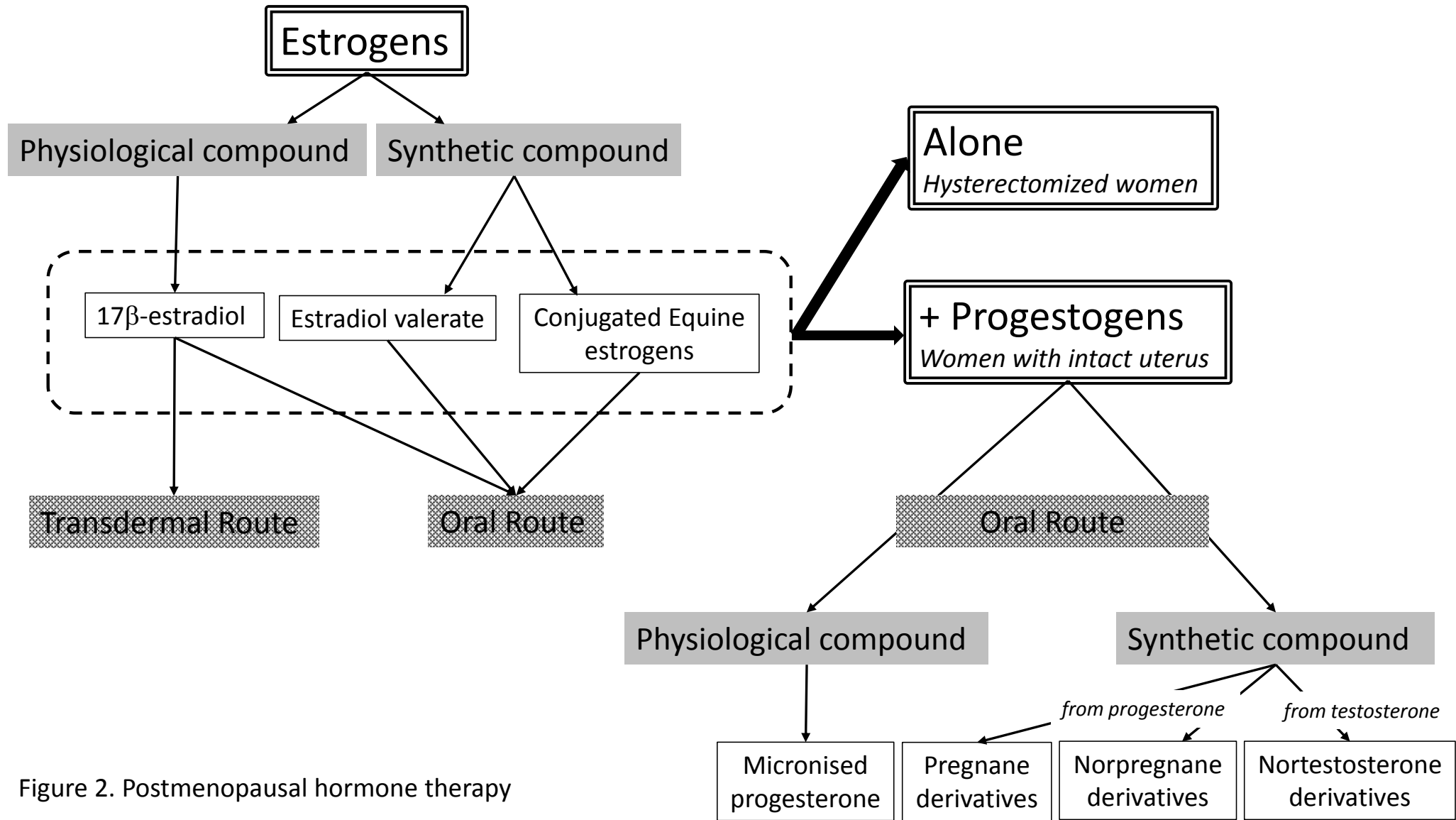


Figure 2. Postmenopausal hormone therapy

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