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Systematic review

Incidence of postpartum hypertension within 2 years of a pregnancy complicated by pre-eclampsia: a systematic review and meta-analysis

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Background Women with a history of hypertensive disorders of pregnancy (HDP) are at increased long-term risk of cardiovascular disease. However, there has been increasing evidence on the same risks in the months following birth.

Objectives This review aims to estimate the incidence of hypertension in the first 2 years after HDP.

Search strategy MEDLINE, Embase and Cochrane databases were systematically searched in October 2019.

Selection criteria Observational studies comparing hypertension rate following HDP and normotensive pregnancies up to 2 years.

Data collection and analysis A meta-analysis to calculate the odds ratio (OR) with a 95% confidence interval (CI) and a sub-group analysis excluding women with chronic hypertension were performed.

Main results Hypertension was diagnosed within the first 2 years following pregnancy in 468/1646 (28.4%) and 584/6395 (9.1%) of the HDP and control groups, respectively (OR 6.28; 95% CI 4.18–9.43; I^2 = 56%). The risk of hypertension in HDP group was significantly higher in the first 6 months following delivery (OR 18.33; 95% CI 1.35–249.48; I^2 = 84%) than at 6–12 months (OR 4.36; 95% CI 2.81–6.76; I^2 = 56%) or between 1–2 years postpartum (OR 7.24; 95% CI 4.44–11.80; I^2 = 9%). A sub-group analysis demonstrated a similar increase in the risk of developing postpartum hypertension after HDP (OR 5.75; 95% CI 3.92–8.44; I^2 = 49%) and pre-eclampsia (OR 6.83; 95% CI 4.25–10.96; I^2 = 53%).

Conclusions The augmented risk of hypertension after HDP is highest in the early postpartum period, suggesting that diagnosis and targeted interventions to improve maternal cardiovascular health may need to be commenced in the immediate postpartum period.

Keywords Cardiovascular disease prevention, hypertension, meta-analysis, pre-eclampsia, pregnancy and postpartum.

Tweetable abstract The risk of hypertension within 2 years of birth is six-fold higher in women who experienced pre-eclampsia.

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Introduction

Hypertensive disorders of pregnancy (HDP) that include pre-eclampsia, eclampsia, HELLP syndrome and gestational hypertension affect about 10% of pregnancies and have a deleterious effect on future maternal cardiovascular outcomes. Women with a history of HDP have an increased risk of coronary artery disease, cerebrovascular disease, peripheral arterial disease and cardiovascular-related mortality to such an extent that pre-eclampsia and gestational hypertension were included by the American Heart Association among major risk factors for cardiovascular disease.[1–3] The augmented risk of cardiovascular disease is mainly due to the fact that women develop essential

hypertension in the years following an HDP index pregnancy.[4,5] In addition, the risk of developing hypertension and other cardiovascular disorders is higher in women with recurrent HDP than in those with a single episode of HDP.[6,7] Therefore, early diagnosis and targeted intervention of hypertension may play a key role in improving future cardiovascular health in women with a previous pregnancy affected by HDP.

The risk of developing cardiovascular disorders after HDP has been mostly assessed by large cohort studies examined several decades after delivery. In one meta-analysis which included about 3 million women between 1960 and 2006, the estimated relative risk (95% confidence intervals) of hypertension after pre-eclampsia was 3.70 (2.70–5.05) after 14 years mean follow up.[8] However, more recent evidence on the timing of hypertension following HDP pregnancy has suggested that women may develop hypertension within months or few years after giving birth. A register-based cohort study on 1.5 million primiparas demonstrated that the rate of antihypertensive medication use within 1 year of a HDP pregnancy was higher compared with normotensive pregnancy (11 versus 0.5%, respectively).[4] In a smaller prospective cohort study of 200 women 1 year after severe pre-eclampsia, 41.5% of women had hypertension presenting as sustained hypertension (14.5%), masked hypertension (17.5%) or hypertension only in a clinical setting (9.5%).[9] These observations are corroborated by the findings that asymptomatic moderate-severe cardiac dysfunction/hypertrophy was observed more frequently in preterm pre-eclampsia (56%) compared with term pre-eclampsia (14%) or matched controls (8%).[10]

Elucidating the temporal pattern and magnitude of hypertension after a pregnancy affected by HDP would help to design and deliver cardiovascular disease preventive strategies after HDP. The aim of this study is to review and analyse the available literature reporting the incidence of hypertension in the first 2 years after HDP compared with uncomplicated pregnancy.

Materials and methods

Protocol, eligibility criteria, information sources and search

This review was performed according to a priori designed protocol recommended for systematic review and meta-analysis.[11] MEDLINE, Embase and Cochrane Library databases were searched electronically in October 2019, utilising combinations of the relevant medical subject heading (MeSH) terms, key words and word variants for 'pre-eclampsia', 'hypertensive disorders of pregnancy', 'essential hypertension' and 'postpartum period' (Appendix S1). The search and selection criteria were restricted to human studies. No time or language restrictions were applied. Conference abstract, case reports, letters and editorials were excluded. Reference lists of relevant articles and reviews were hand-searched for additional reports. PRISMA and MOOSE guidelines were followed.[12–14] The study was registered with the PROSPERO database (Registration number: CRD42019149123).

Study selection, data collection and data items

The primary outcome was to assess the incidence of hypertension after pregnancies complicated by HDP that include pre-eclampsia, eclampsia, HELLP syndrome and gestational hypertension within 2 years postpartum. We included case-control and cohort studies that presented data on how many patients suffer from hypertension from 6 weeks up to 2 years postpartum. The whole time period was divided into three groups: up to 6 months, 6 months–1 year, 1–2 years. Hypertension was defined when systolic blood pressure (SBP) ≥140 mm Hg and/or diastolic blood pressure (DBP) ≥90 mm Hg occurs more than one occasion in a clinical setting.[15] The use of antihypertensive medication and lower approved cut-offs to define hypertension were also included as diagnostic criteria.[16] When data were available, only cases affected by pre-eclampsia were considered in the analysis. We excluded studies where chronic hypertension pre-existing the index pregnancy or developing before 20 weeks was not clearly defined. If a study included patients with chronic hypertension, we considered only articles that provided the number of patients affected by chronic hypertension. Moreover, we did not include articles with incidence rates and cumulative incidence of postpartum hypertension after HDP beyond 2 years postpartum.

All abstract screening was performed independently by two researchers (VG, AR). The full text of those potentially eligible studies was retrieved and independently assessed for eligibility by the two researchers (VG, AR). Any inconsistency or disagreement was discussed with a third reviewer (EK) and a consensus was reached. A few articles in a language other than English were translated to decide whether they would be suitable for inclusion. A reviewer (VG) extracted data regarding study characteristics and outcomes, in particular, author, year, location, study type, population size, inclusion criteria, exclusion criteria, reported outcomes, blood pressure assessment method and setting, hypertension definition and time of measurement. If more than one study was published for the same cohort with equal endpoints, the report containing the most comprehensive information on the population was used to avoid overlapping populations. For those articles in which information was not reported but where the methodology showed that this information would have been recorded initially, the authors were contacted.

Patients were not involved in the development of this study and a core outcome set was not used.

Quality assessment of the included studies was performed using the Newcastle-Ottawa Scale (NOS) for cohort and case-control studies. According to NOS, each study was judged on three broad perspectives: the selection of the study groups, the comparability of the groups, and the ascertainment of outcome of interest or exposure. Assessment of the selection of a study includes the evaluation of the representativeness of the exposed cohort, selection of the non-exposed cohort, ascertainment of exposure and the demonstration that the outcome of interest was not present at the start of study. Assessment of the comparability of the study includes the evaluation of the comparability of groups based on the design or analysis. Finally, the ascertainment of the outcome of interest includes the evaluation of the type of the assessment of the outcome of interest, length and adequacy of follow up, whereas the ascertainment of the exposure includes the evaluation of the type of the assessment of the exposure for cases and controls and the non-response rates. According to NOS, a study can be awarded a maximum of one star for each numbered item within the Selection and Outcome/Exposure categories. A maximum of two stars can be given for Comparability.[17]

The overall quality of evidence for the outcome was assessed using a Grading of Recommendations Assessment, Development and Evaluation (GRADE) system that rates fields, namely, risk of bias, inconsistency, indirectness, imprecision, publication bias, large effect, plausible confounding and dose response gradient, in order to obtain different categories for the quality of a body of evidence (high, moderate, low, very low). This reflects the degree of confidence of how near our estimate of the effect lies to the true effect; the level of confidence decreases with decreasing quality.[18,19]

Statistical analysis

The risk of hypertension after HDP and uncomplicated pregnancy was calculated pooling respectively events and cases of all studies. The tables including raw outcome data were used to calculate the overall combined odds ratio (OR) with its 95% confidence interval (CI). To obtain a more precise risk estimate of postpartum hypertension in women with HDP during their pregnancy, a meta-analysis was performed using a random effects model because of the high level of heterogeneity among the selected studies. The significance of the combined OR calculated using the Mantel-Haenszel statistical method was determined by the Z-test and the *P*-value. A continuity correction technique was used to handle zero count cells in the tables. The variance between the studies was tested using the I^2 statistics. The I^2 index expresses the percentage of the total variation across studies that is due to heterogeneity. I^2 values of 25, 50 and 75% correspond to low, moderate and high heterogeneity, respectively. Meta-regression was carried out using a mixed-effects model. Sub-analyses were planned for factors significantly contributing to the statistical heterogeneity. As the number of included studies was adequate, the publication bias was explored with funnel plot asymmetry tests. Statistical analyses were performed using R for statistical computing software (R Foundation).

Results

General characteristics

Fifteen studies were included in the systematic review after assessing 223 articles in full text with respect to their eligibility for inclusion from the 8407 articles identified through the search (Figure 1, Tables S1 and S2).[10,20–33] Among these studies, 14/15 were cohort studies and 1/15 was a case-control study. The total population sample size ranged from 28 to 5105 patients and follow up from 2 to 24 months postpartum. Four studies included women with chronic hypertension pre-dating the index pregnancy,[22,23,26,30] and three of four provided the outcome data without these cases.[22,23,30] In 11 studies the authors reported the technique of blood pressure measurement: in 4 studies, hypertension was diagnosed using a standard sphygmomanometer,[10,20,25,33] and in seven 11, an automatic device was employed.[21,22,24,27,28,31,32] In addition, in one study the incidence of hypertension was self-reported by patients using a standardised questionnaire.[23] The cut-off of SBP/DBP to define hypertension in an office setting was defined in 12 studies; it was 140/90 mmHg in 10/12 studies,[10,20,22,24,25,27,28,30–33] 130/80 in one study[25] and 120/80 in one study.[21] Table S2 shows that women with a history of HDP were more likely to have a higher body mass index than controls in seven studies (46.7%)[10,21,22,26,29,30,33] and to be older than controls in five studies (33.3%).[21,23,26,29,33] The number of cases of early-onset pre-eclampsia was reported by four papers,[23,26,32,33] and those of HDP that required delivery before 37 weeks were described in other four studies.[10,20,24,27]

Synthesis of the results

Overall, 1646 women with a history of HDP were compared with 6395 women with a uneventful previous pregnancy (Figure 2). The total number of women who developed hypertension in the first 2 years was 468/1646 (28.4%) and 584/6395 (9.1%) in the HDP and control group, respectively (OR 6.28; 95% CI 4.18–9.43; I^2 = 56%). The OR of postpartum hypertension in HDP group was 18.33 (95% CI 1.35–249.48; I^2 = 84%) in the period up to 6 months, 4.36 (95% CI 2.81–6.76; I^2 = 56%) in the period from 6 months up to 1 year, and 7.24 (95% CI 4.44–11.80; I^2 = 9%) between 1 and 2 years. Data on pre-eclampsia were reported by 13 studies. Figure S1 shows the comparisons of the postpartum

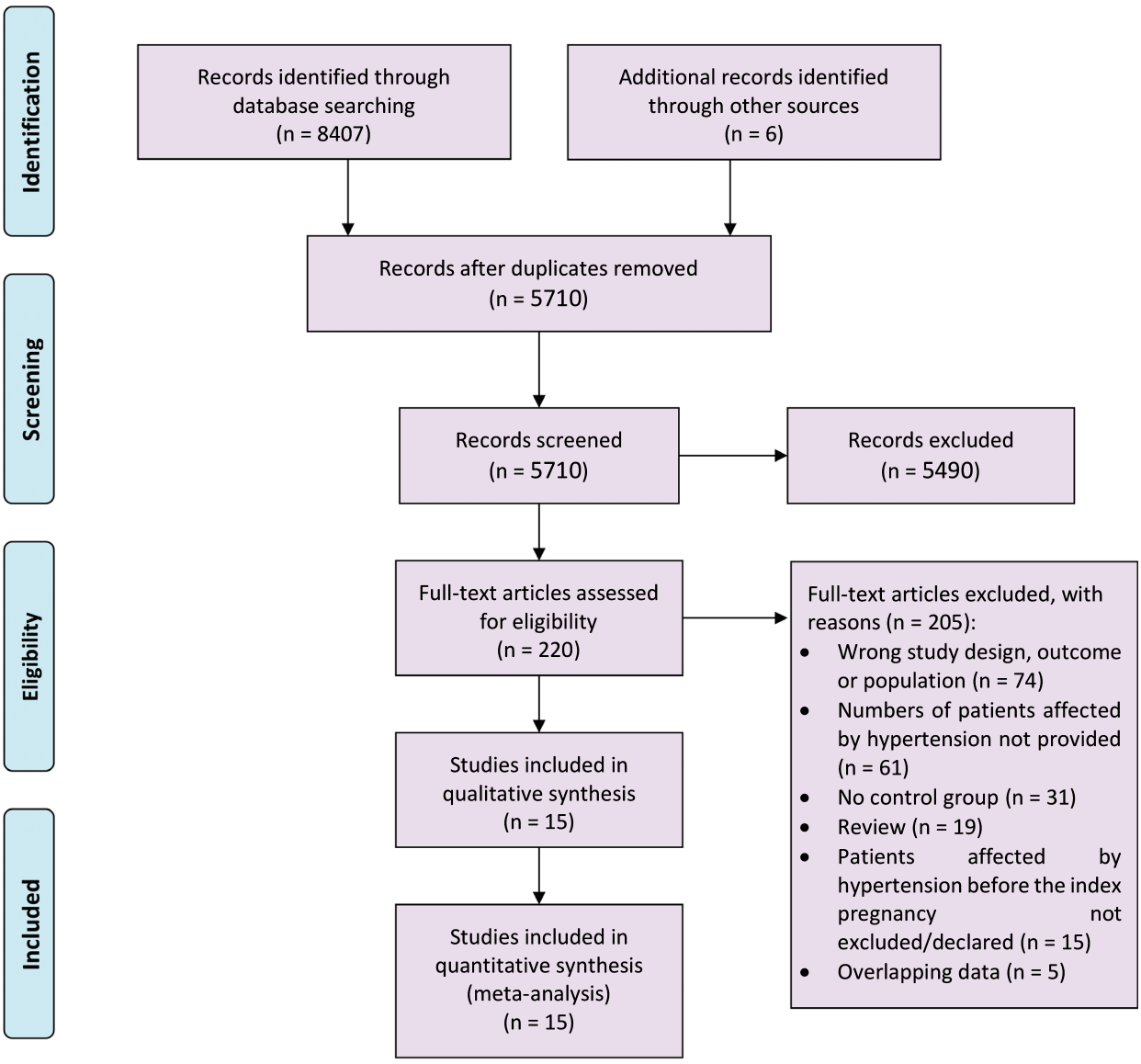

Figure 1. PRISMA flow diagram.

incidence of hypertension in women affected by pre-eclampsia and controls. In the pooled analysis an increased risk of hypertension was observed for pre-eclampsia (OR 7.49; 95% CI 4.58–12.26). Heterogeneity among the studies was moderate (I^2 = 60%). The same trend of HDP has been observed in the different time periods up to 2 years (up to 6 months, OR 57.08; 95% CI 11.00–296.07; 6 months to 1 year, OR 4.83; 95% CI 2.78–8.37; 1–2 years, OR 7.44; 95% CI 4.19–13.21). The heterogeneity was 0% up to 6 months, 58% at 6 months to 1 year, and 20% at 1–2 years. In both meta-analyses, heterogeneity was explained to some extent (45.3% and 36.9%, respectively) by the incidence of chronic hypertension as showed by meta-regression (P = 0.034 and 0.092, for HDP and PE models, respectively). Therefore, a sub-group analysis excluding this population was conducted.

Sub-group analysis

Fourteen studies were eligible for the sub-group analysis because they excluded women with pre-existing hypertension in calculating the outcome. Among them, data on pre-eclampsia were reported by 12 studies. Pooled results of studies excluding hypertension before the index pregnancy reported an overall OR of 5.75 (95% CI 3.92–8.44; I^2 = 49%) for the risk of developing postpartum hypertension in women with a history of HDP compared with women without (Figure 3). The OR is reported at 13.39 (95% CI 1.27–141.04; I^2 = 72%),

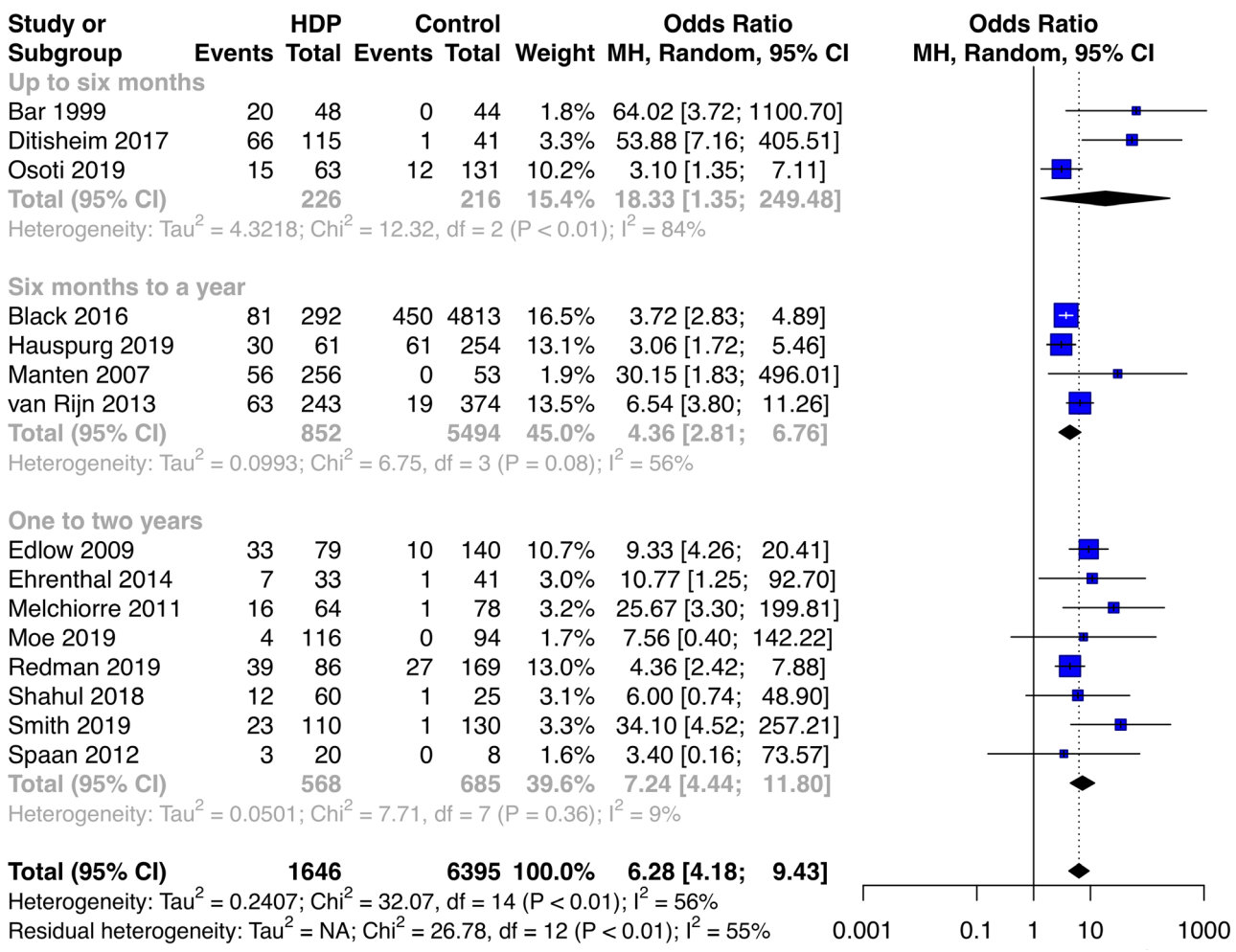

Figure 2. The incidence of hypertension after hypertensive disorders of pregnancy (HDP) up to 2 years postpartum.

4.13 (95% CI 2.82–6.07; I^2 = 54%) and 8.73 (95% CI 4.66–16.35; I^2 = 23%) in the period up to 6 months, between 6 months and 1 year, and between 1 and 2 years, respectively. Considering only data on pre-eclampsia, women with a pregnancy complicated by pre-eclampsia were at a significantly increased risk of postpartum hypertension compared with women with normotensive pregnancy (OR 6.83, 95% CI 4.25–10.96; I^2 = 53%) with the following discrepancies among the different periods: up to 6 months, OR 43.95 (95% CI 5.72–338.04; I^2 = 0%); 6 months to 1 year, OR 4.46 (95% CI 2.76–7.21; I^2 = 56%); 1–2 years, OR 8.91 (95% CI 4.33–18.33; I^2 = 33%) (Figure S2).

Publication bias, study quality and quality of evidence

No evidence of publication bias has been detected in studies including women with pregnancies affected by HDP (P = 0.890) or pre-eclampsia (P = 0.666), as illustrated by funnel plots (Figures S3 and S4). The NOS quality scores were high among five of the 15 studies with a NOS score of 8 (Table S1). The mean ± SD overall score for all 15 studies was 6.9 ± 1.0. The quality of evidence, according to GRADE, was calculated for the incidence of hypertension after HDP and after pre-eclampsia. In the former analysis, it was low for the results obtained up to 6 months and from 6 month to 1 year, and was moderate for the incidence of hypertension assessed between 1 and 2 years (Table S3). In the latter analysis, the quality of evidence was moderate in the first and last periods and low between 6 months and 1 year (Table S4). The low/moderate quality of evidence was mainly because any study design other than randomised controlled trials carries a high risk of bias. The difference in the quality of evidence among different periods was due to the magnitude of association and the impact of the 'risk of bias' and/or 'inconsistency' parameters (Tables S3 and S4).

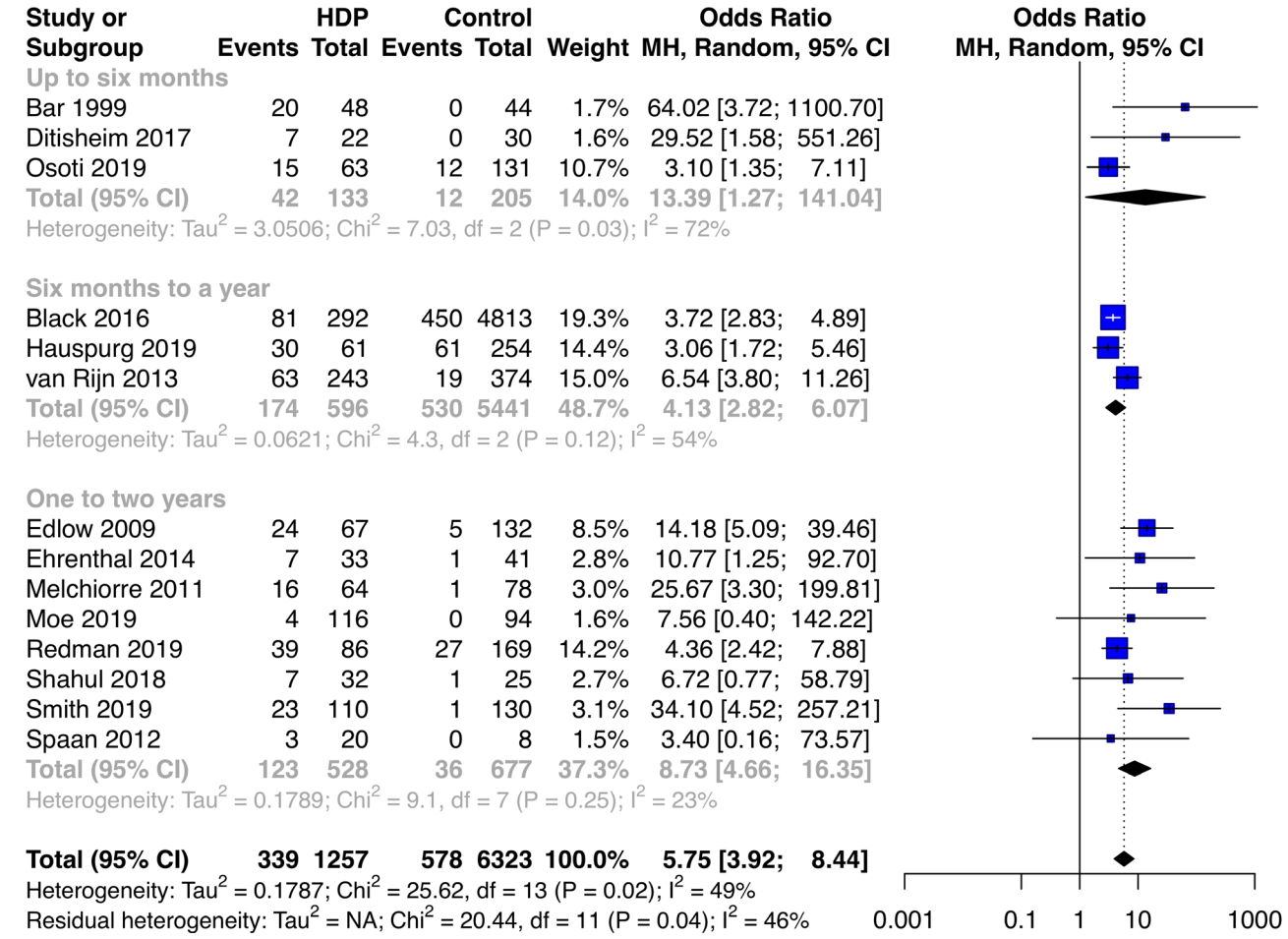

Figure 3. The incidence of hypertension after hypertensive disorders of pregnancy (HDP) up to 2 years postpartum (excluding cases with chronic hypertension).

Discussion

Main findings

The risk of developing hypertension within 2 years after delivery in women with a history of HDP is six-fold higher compared with women after a normotensive pregnancy. A sub-group analysis of studies where pre-existing hypertension was excluded, revealed that there is a similar overall OR and trend for developing hypertension in the three postpartum periods analysed, with the risk being more than ten-fold in the first 6 months, four-fold at 6 months to 1 year, and eight-fold at 1–2 years.

Strengths and limitations

This systematic review elucidates the magnitude of the risk of developing hypertension within the first 2 years after delivery in women who experienced HDP in the index pregnancy by a comprehensive review and analysis of the current literature. We included studies in which HDP was precisely defined and where women with chronic hypertension were excluded or defined clearly.

However, the current study has some limitations that should be considered. First, the quality assessment of the studies showed that only five studies reached a score ≥8. Furthermore, the quality of evidence is low or moderate according to GRADE and therefore caution is needed when interpreting the results. For instance, only around one-third of the studies reported a significantly higher maternal age in women with a history of HDP than seen in controls. This could be due to a selection bias of the control group, in particular in the smaller studies, and might explain why the control group had a relatively high risk of hypertension (9.1%).

Secondly, the risk of hypertension was highest in the immediate postpartum period (<6 months). However, this might be due to an overestimation of the risk because of the paucity of studies in this time period or to a delayed resolution of pregnancy hypertension. However, Behrens

et al.[4] also described the highest risk of developing hypertension in the year after delivery compared with the following years after excluding prescription of any antihypertensive drug that could be related to a treatment for HDP (i.e. use of antihypertensive from 20 weeks of gestation up to 3 months postpartum).

Another aspect to be addressed regarding the immediate postpartum period is when follow up should be started after delivery. We included studies reporting outcomes after 6 weeks postpartum but we acknowledge that the literature regarding the time when pre-eclampsia resolves is unclear. Guidelines reported 6 weeks or 3 months as the point where normalisation of blood pressure after pre-eclampsia would be expected.[34,35] Thus, current evidence from the published literature is not enough to define the best screening period postpartum to detect hypertension.

Thirdly, heterogeneity in populations and in hypertension definitions, in addition to the failure to obtain sufficient details could make the results of meta-analysis misleading and impossible to adjust using statistical tests.

Interpretation

This review quantifies the risk of hypertension in the immediate postpartum period after a pregnancy complicated by HDP, highlighting the importance of early diagnosis and intervention for hypertension in this period. These results are consistent with growing evidence of the association between HDP and cardiovascular diseases; however, prior research and meta-analysis were focused on the long-term consequences rather than those soon after delivery.[8,36] The results of studies with more immediate cardiovascular follow up after delivery (and the current meta-analysis) provide more reliable data on the development of cardiovascular diseases after delivery. The Nurses' Health Study II demonstrated that women who reported a first pregnancy affected by HDP presented higher rates of hypertension (hazard ratio [HR] 2.8; 95% CI 2.6–3.0), type 2 diabetes mellitus (HR 1.7; 95% CI 1.4–1.9) and hypercholesterolaemia (HR 1.4; 95% CI 1.3–1.5) within 5 years postpartum.[37] A recent prospective observational cohort that followed 4484 women for a mean of 3.2 years after their first pregnancy showed that women with any hypertensive disorder of pregnancy had a higher adjusted risk of hypertension at follow up compared with controls (relative risk [RR] 2.7; 95% CI 2.0–3.6).[38] Moreover, a register-based study showed that women with HDP had twice the risk of cardiovascular readmissions (acute myocardial infarction, stroke or heart failure) within 3 years compared with women with normal pregnancies.[39] One case-control study (n = 142) demonstrated an elevated risk of hypertension 2 years after delivery for women with pre-eclampsia.[10] Lastly, a large Danish register-based cohort study with a ten-year follow up revealed that rates of persistent hypertension were 12- to 25-fold higher in the first year after delivery and 4- to 10-fold higher between 1 and 5 years in women with a hypertensive disorder of pregnancy than in women with a normotensive pregnancy.[4]

The temporal shift from decades to early postpartum years in maternal cardiovascular care highlights the need to bridge the gap between obstetric care and adult preventive medicine.[40] An awareness campaign about the significance of a history of pregnancy complications should be focused on family practitioners and cardiovascular specialists. Also, given the earlier risk of developing hypertension in women after HDP, serial blood pressure monitoring should be scheduled in the first months to years following birth. It would appear useful to evaluate blood pressure measurements at 8–12 weeks postpartum and again within 2 years

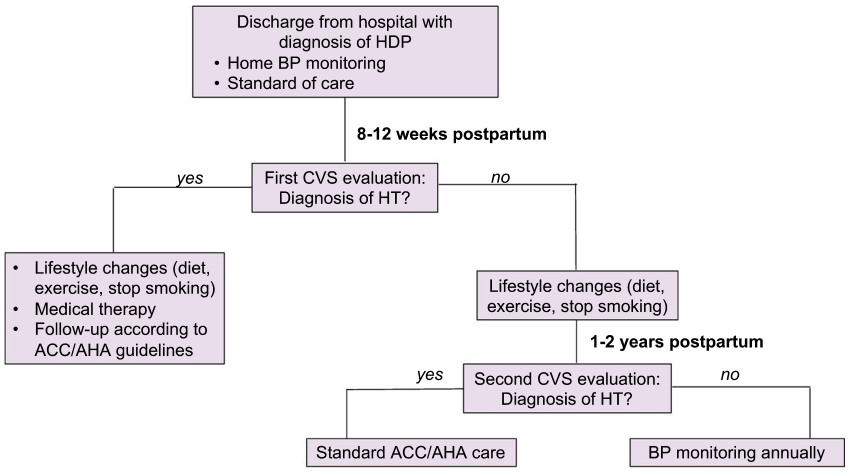

Figure 4. Flow-chart for cardiovascular system evaluation after hypertensive disorders of pregnancy. ACC/AHA, American College of Cardiology/American Heart Association; BP, blood pressure; CVS, cardiovascular system; HDP, hypertensive disorders of pregnancy; HT, hypertension.

of the index HDP pregnancy. If hypertension is diagnosed, lifestyle changes, medical therapy and standard follow up should be highly encouraged (Figure 4). To support such proposals, a prospective blood pressure screening trial should be conducted to understand the optimal regimen for monitoring blood pressure after previous HDP.

This systematic review shows that there is a paucity of research in the first months after delivery compared with the following years. This research should be focused on developing effective screening, follow up and targeted intervention strategies for women after pre-eclampsia, presenting a unique opportunity for early intervention. In particular, no research has investigated how to identify subjects at increased risk of cardiovascular diseases among women with HDP or pre-eclampsia in the peripartum period. Some cardiac functional abnormalities, such as diastolic dysfunction, left ventricular remodelling and reduced left ventricular contractility in the peripartum period may be unique markers to identify women at higher risk of future cardiovascular diseases.

Conclusion

This systematic review defines the risk of developing hypertension in the first 2 years after a hypertensive pregnancy and highlights the window of opportunity for cardiovascular prevention in women with a diagnosis of hypertension after delivery.

Disclosure of interests

None declared. Completed disclosure of interest forms are available to view online as supporting information.

Contribution to authorship

VG screened abstracts, selected eligible papers, extracted data and wrote the first draft of the paper. AR screened abstracts and selected eligible papers. EK performed the statistical analysis and helped in the final selection of papers in case of disagreement. AK reviewed the manuscript critically. BT designed the study and revised the manuscript.

Details of ethics approval

Not applicable.

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None.

Supporting Information

Additional supporting information may be found online in the Supporting Information section at the end of the article.

Figure S1. Incidence of hypertension after pre-eclampsia (PE) up to 2 years postpartum.

Figure S2. Incidence of hypertension after pre-eclampsia (PE) up to 2 years postpartum (excluding cases with chronic hypertension).

Figure S3. Funnel plots of studies including women with hypertensive disorders of pregnancy.

Figure S4. Funnel plots of studies including women with pre-eclampsia.

Table S1. Descriptive information of studies included in the systematic review.

Table S2. Population characteristics.

Table S3. GRADE assessment for incidence of hypertension after hypertensive disorders of pregnancies.

Table S4. GRADE assessment for incidence of hypertension after pre-eclampsia.

Appendix S1. Search strategy. ■

References

1 Grandi SM, Filion KB, Yoon S, Ayele HT, Doyle CM, Hutcheon JA, et al. Cardiovascular disease-related morbidity and mortality in women with a history of pregnancy complications. *Circulation* 2019;139:1069–79.

2 Mosca L, Benjamin EJ, Berra K, Bezanson JL, Dolor RJ, Lloyd-Jones DM, et al. Effectiveness-based guidelines for the prevention of cardiovascular disease in women–2011 update: a guideline from the American Heart Association. *J Am Coll Cardiol* 2011;57:1404–23.

3 Ray JG, Vermeulen MJ, Schull MJ, Redelmeier DA. Cardiovascular health after maternal placental syndromes (CHAMPS): population-based retrospective cohort study. *Lancet* 2005;366:1797–803.

4 Behrens I, Basit S, Melbye M, Lykke JA, Wohlfahrt J, Bundgaard H, et al. Risk of post-pregnancy hypertension in women with a history of hypertensive disorders of pregnancy: nationwide cohort study. *BMJ* 2017;12:j3078.

5 Benschop L, Duvekot JJ, Roeters van Lennep JE. Future risk of cardiovascular disease risk factors and events in women after a hypertensive disorder of pregnancy. *Heart* 2019;105:1273–8.

6 Brouwers L, van der Meiden-van Roest AJ, Savelkoul C, Vogelvang TE, Lely AT, Franx A, et al. Recurrence of pre-eclampsia and the risk of future hypertension and cardiovascular disease: a systematic review and meta-analysis. *BJOG* 2018;125:1642–54.

7 Lykke JA, Langhoff-Roos J, Sibai BM, Funai EF, Triche EW, Paidas MJ. Hypertensive pregnancy disorders and subsequent cardiovascular morbidity and type 2 diabetes mellitus in the mother. *Hypertension* 2009;53:944–51.

8 Bellamy L, Casas JP, Hingorani AD, Williams DJ. Pre-eclampsia and risk of cardiovascular disease and cancer in later life: systematic review and meta-analysis. *BMJ* 2007;335:974.

9 Benschop L, Duvekot JJ, Versmissen J, van Broekhoven V, Steegers EAP, Roeters van Lennep JE. Blood pressure profile 1 year after severe preeclampsia. *Hypertension* 2018;71:491–8.

10 Melchiorre K, Sutherland GR, Liberati M, Thilaganathan B. Preeclampsia is associated with persistent postpartum cardiovascular impairment. *Hypertension* 2011;58:709–15.

11 Henderson LK, Craig JC, Willis NS, Tovey D, Webster AC. How to write a Cochrane systematic review. *Nephrology* 2010;15:617–24.

12 Moher D, Liberati A, Tetzlaff J, Altman DG, PRISMA Group. Preferred reporting items for systematic reviews and meta-analyses: the PRISMA statement. *BMJ* 2009;21:b2535.

13 Zorzela L, Loke YK, Ioannidis JP, Golder S, Santaguida P, Altman DG, et al. PRISMA harms checklist: improving harms reporting in systematic reviews. *BMJ* 2016;1:i157.

14 Stroup DF, Berlin JA, Morton SC, Olkin I, Williamson GD, Rennie D, et al. Meta-analysis of observational studies in epidemiology: a proposal for reporting. Meta-analysis Of Observational Studies in Epidemiology (MOOSE) group. *JAMA* 2000;283:2008–12.

15 Williams B, Mancia G, Spiering W, Agabiti Rosei E, Azizi M, Burnier M, et al. 2018 ESC/ESH Guidelines for the management of arterial hypertension. *Eur Heart J.* 2018;39:3021–104.

16 Whelton PK, Carey RM, Aronow WS, Casey DE Jr, Collins KJ, Dennison Himmelfarb C, et al. 2017 ACC/AHA/AAPA/ABC/ACPM/AGS/APhA/ASH/ASPC/NMA/PCNA guideline for the prevention, detection, evaluation, and management of high blood pressure in adults: a report of the American College of Cardiology/American Heart Association Task Force on Clinical Practice Guidelines. *Hypertension* 2018;71:e13–15.

17 Newcastle-Ottawa Scale for assessing the quality of non randomised studies in metaanalyses. 2019. [http://www.ohri.ca/programs/clinical_epidemiology/oxford.asp]. Accessed 15 October 2019.

18 Balshem H, Helfand M, Schunemann HJ, Oxman AD, Kunz R, Brozek J, et al. GRADE guidelines: 3. Rating the quality of evidence. *J Clin Epidemiol* 2011;64:401–6.

19 Guyatt G, Oxman AD, Akl EA, Kunz R, Vist G, Brozek J, et al. GRADE guidelines: 1. Introduction-GRADE evidence profiles and summary of findings tables. *J Clin Epidemiol* 2011;64:383–94.

20 Bar J, Kaplan B, Wittenberg C, Erman A, Boner G, Ben-Rafael Z, et al. Microalbuminuria after pregnancy complicated by pre-eclampsia. *Nephrol Dial Transplant* 1999;14:1129–32.

21 Black MH, Zhou H, Sacks DA, Dublin S, Lawrence JM, Harrison TN, et al. Hypertensive disorders first identified in pregnancy increase risk for incident prehypertension and hypertension in the year after delivery. *J Hypertens* 2016;34:728–35.

22 Ditisheim A, Wuerzner G, Ponte B, Vial Y, Irion O, Burnier M, et al. Prevalence of hypertensive phenotypes after preeclampsia: a prospective cohort study. *Hypertension* 2018;71:103–9.

23 Edlow AG, Srinivas SK, Elovitz MA. Investigating the risk of hypertension shortly after pregnancies complicated by preeclampsia. *Am J Obstet Gynecol* 2009;200:e60–2.

24 Ehrenthal DB, Goldstein ND, Wu P, Rogers S, Townsend RR, Edwards DG. Arterial stiffness and wave reflection 1 year after a pregnancy complicated by hypertension. *J Clin Hypertens (Greenwich)* 2014;16:695–9.

25 Hauspurg A, Countouris ME, Jeyabalan A, Hubel CA, Roberts JM, Schwarz EB, et al. Risk of hypertension and abnormal biomarkers in the first year postpartum associated with hypertensive disorders of pregnancy among overweight and obese women. *Pregnancy Hypertens* 2019;15:1–6.

26 Manten GT, Sikkema MJ, Voorbij HA, Visser GH, Bruinse HW, Franx A. Risk factors for cardiovascular disease in women with a history of pregnancy complicated by preeclampsia or intrauterine growth restriction. *Hypertens Pregnancy* 2007;26:39–50.

27 Moe K, Sugulle M, Dechend R, Staff AC. Risk prediction of maternal cardiovascular disease one year after hypertensive pregnancy complications or gestational diabetes mellitus. *Eur J Prev Cardiol* 2019;10:2047487319879791.

28 Osoti AO, Page ST, Richardson BA, Guthrie BL, Kinuthia J, Polyak SJ, et al. Postpartum metabolic syndrome after gestational hypertension and preeclampsia, a prospective cohort study. *Pregnancy Hypertens* 2019;18:35–41.

29 Redman EK, Hauspurg A, Hubel CA, Roberts JM, Jeyabalan A. Clinical course, associated factors, and blood pressure profile of delayed-onset postpartum preeclampsia. *Obstet Gynecol* 2019;134:995–1001.

30 Shahul S, Ramadan H, Nizamuddin J, Mueller A, Patel V, Dreixler J, et al. Activin A and late postpartum cardiac dysfunction among women with hypertensive disorders of pregnancy. *Hypertension* 2018;72:188–93.

31 Smith GN, Pudwell J, Saade GR. Impact of the new American hypertension guidelines on the prevalence of postpartum hypertension. *Am J Perinatol* 2019;36:440–2.

32 Spaan JJ, Ekhart T, Spaanderman ME, Peeters LL. Renal function after preeclampsia: a longitudinal pilot study. *Nephron Clin Pract* 2012;120:c156–61.

33 van Rijn BB, Nijdam ME, Bruinse HW, Roest M, Uiterwaal CS, Grobbee DE, et al. Cardiovascular disease risk factors in women with a history of early-onset preeclampsia. *Obstet Gynecol* 2013;121:1040–8.

34 Brown MA, Magee LA, Kenny LC, Karumanchi SA, McCarthy FP, Saito S, et al. The hypertensive disorders of pregnancy: ISSHP classification, diagnosis & management recommendations for international practice. *Pregnancy Hypertens* 2018;13:291–310.

35 Webster K, Fishburn S, Maresh M, Findlay SC, Chappell LC, Guideline C. Diagnosis and management of hypertension in pregnancy: summary of updated NICE guidance. *BMJ* 2019;9:l5119.

36 Brown MC, Best KE, Pearce MS, Waugh J, Robson SC, Bell R. Cardiovascular disease risk in women with pre-eclampsia: systematic review and meta-analysis. *Eur J Epidemiol* 2013;28:1–19.

37 Stuart JJ, Tanz LJ, Missmer SA, Rimm EB, Spiegelman D, James-Todd TM, et al. Hypertensive disorders of pregnancy and maternal cardiovascular disease risk factor development: an observational cohort study. *Ann Intern Med* 2018;169:224–32.

38 Haas DM, Parker CB, Marsh DJ, Grobman WA, Ehrenthal DB, Greenland P, et al. Association of adverse pregnancy outcomes with hypertension 2 to 7 years postpartum. *J Am Heart Assoc* 2019;8:e013092.

39 Jarvie JL, Metz TD, Davis MB, Ehrig JC, Kao DP. Short-term risk of cardiovascular readmission following a hypertensive disorder of pregnancy. *Heart* 2018;104:1187–94.

40 Thilaganathan B, Kalafat E. Cardiovascular system in preeclampsia and beyond. *Hypertension* 2019;73:522–31.

