An Assessment of the Efficacy of Various-Length Courses of Sulphide Balneopeloidotherapy for Essential Hypertension

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Abstract: The study conducted a comparative analysis of the efficacy of sulphide balneopeloidotherapy spanning 21 and 14 days with the inclusion of local magnetotherapy and without. The study examined 140 patients with essential hypertension (EH), who had first- and second-degree arterial hypertension (AH), before and after the course of spa therapy. It was established that the 21-day course results in a marked hypotensive effect, normalizes the diurnal rhythm of arterial blood pressure (AP), reduces the level of endothelial dysfunction, the level of blood lipids and the activity of the sympathetic division of the autonomous nervous system (ANS). Shortening the course down to 14 days diminishes the markedness of the hypotensive effect. The inclusion of variable-magnetic-field magnetopuncture (VMFMP) in the treatment optimizes the results of the treatment.

Key words: Arterial hypertension · Sulphide balneopeloidotherapy · Magnetotherapy

INTRODUCTION

Arterial hypertension (AH) is common in most developed countries of the world [1-5]. According to the findings of examinations conducted in different regions of Russia, the incidence of AH within the RF population is 39.7% [6,7,8]. AH is the number one contributor to mortality from cardiovascular diseases, which makes rational treatment of AH one of the most topical issues in modern cardiology. Along with medicamental methods for treating AH, sanatorium-and-spa treatment is widely used [9], including sulphide balneotherapy whose efficacy has been substantiated by numerous studies [10,11].

Until recently, the duration of treatment for essential hypertension (EH) at a spa resort was 21-24 days. Presently, over 80% of patients normally stay at a spa resort for no longer than 14 days. The efficacy of shortened EH treatment courses has been studied insufficiently and is doubted. To optimize spa therapy, physical treatment factors are used, including acting upon biologically active points with variable magnetic fields. The efficacy of combined application of shortened courses of sulphide balneotherapy and local magnetotherapy has been studied insufficiently.

Aims of the Study: Assessing the efficacy of various-length courses of sulphide balneopeloidotherapy for essential hypertension in combination with local magnetotherapy and without it.

Materials and Methods of the Study: The study examined 140 first- and second-stage EH patients with first- and second-degree AH. Depending on the variant of treatment, the patients were divided into 3 groups. In the 1st stage (the 1st study group), the study investigated the efficacy of classic, duration-wise, courses of spa treatment. The group consisted of 20 patients who underwent balneo- and peloidotherapy over a period of 21 days. In the 2nd stage, the study examined the efficacy of courses of treatment shortened down to 14 days.

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In this stage, the study examined 2 types of treatment (the 2nd and 3rd study groups). The 2nd group consisted of 50 patients who received Diet No. 10 and underwent balneo- and peloidotherapy over a period of 14 days. The 3rd group consisted of 50 patients who received Diet No. 10, general sulfurated hydrogen baths, applications of silt sulphide mud in combination with local magnetotherapy (10 sessions) over a period of 14 days.

The patients were before and after the treatment diurnally (i.e. throughout each 24-hour period) monitored for AP (AHDM), assessed for changes in endothelium-dependent vasodilation (EDVD) of the shoulder artery in conducting reactive hyperemia testing using the methodology by D. Celemajer et al. [12] and the state of the autonomous nervous system (ANS) using cardiointervalography (CIG) and diurnally monitored for electrocardiography (ECGDM). All the patients were examined before and after the treatment at the *Kluychi* spa resort in Perm Krai. To assess the credibility of the statistical analysis of numeric data, parametric and non-parametric statistics methods were used. Differences between independent samples with a normal data distribution were assessed using the Student criterion and those between two independent samples with an unknown and incorrect distribution were assessed using the Whitney-Mann and Wilcoxon criteria. In analyzing all the types, the differences were considered to be statistically significant at $p < 0,05$.

The Efficacy of the 21-Day Course of Balneopeloidotherapy: The study investigated the dynamic of complaints. Before the treatment, out of 20 patients examined, 12 had complained of headache, 5 – instances of dizziness and 15 – a feeling of heaviness in the head. As a result of the treatment, headaches and heaviness in the head were cleared in the patients.

The study registered the dynamic of indicators of the diurnal monitoring of arterial pressure (APDM). The study investigated the markedness of the hypotensive effect depending on the degree of arterial hypertension (AH). In the patients with first-degree AH, there was a decrease in systolic arterial pressure (SAP) in the daytime from 131,2±10,5 down to 113,0±4,9 mm Hg, p<0,001 and in the nighttime - from 124,9±9,4 down to 105,1±12,8 mm Hg, p<0001; diastolic arterial pressure (DAP) in the daytime – from 81,0±6,3 down to 75,3±6,5 mm Hg, p<0,001 and in the nighttime - from 72,7±2,9 down to 65,9±4,2 mm Hg, p<0,001. In the patients with second-degree AH, SAP in the daytime diminished from 164,8±3,7 down to 140,7±6,8 mm Hg, p<0,001 and in the nighttime - from 145,1±12,8

down to 120,8±8 mm Hg, p<0,001; DAP in the daytime – from 97,1±4,7 down to 83,1±6,5 mm Hg, p<0,001 and in the nighttime - from 82,5±8,8 down to 70,9±2,7 mm Hg, p<0,001. In addition, the study investigated the dynamic of indicators of blood pressure load within a 24-hour period. The study revealed a verifiably positive dynamic of the time (TI) and square indexes (SI): the TI of SAP before the treatment was 68,83±11,5 and after the treatment - 32,33±8,16, p=0,05; the TI of DAP before the treatment was 39,57±6,05 and after the treatment - 20,01±8,30, p=0,05; the SI of SAP before the treatment was 99.67±36.38, p<0,05 and after the treatment - 10.88±15.52; the SI of DAP before the treatment was 143.5±6.4, p<0,05 and after the treatment – 56,5±7,07 mm^2, p<0,02.

The study assessed the diurnal rhythm of AP by the diurnal index (DI). The study revealed an increase in the DI in the patients with disruption of the circadian rhythm of AP of the "non-dipper" and "night-peaker" type, which attests to the treatment's normalizing effect on this process. The study revealed no change in the DI in patients with any disruption of the diurnal rhythm of AP (the "dipper" group).

The patients received diurnal ECG monitoring. The study registered a heart rate fall in the daytime and nighttime (p <0,05). The average number of extrasystoles diminished after the treatment from 45± 12,35 down to 29,31±13,83, p <0,05. No changes in the terminal part of the QRS complex were detected.

The study examined echocardiogram (EchoCG) results before and after the treatment. After the course of balneo-mud treatment spanning 21 days, the study detected a little increase in ejection fraction (EF) (EF before the treatment was 54,7±0,8% and after the treatment - 56,9±1,4%, p <0,05) and a normalization of the E/A ratio of diastolic function (before the treatment - 0,78±0,67 and after the treatment - 1,02±0,12, p <0,05). The assessment of endothelial function revealed an improvement after the course of treatment. In this regard, the increase in the diameter of the shoulder artery in conducting reactive hyperemia testing using the methodology by D. Celemajer *et al*., before the treatment was 3,6±3,1 % and after the treatment - 8,3±3,2% (p=0,000).

The study examined the state of the autonomous nervous system (ANS) using cardiointervalography (CIG). After the course of balneo-mud treatment, the study revealed a decrease in the sympathetic tonus, which is attested to by a decrease in the mode amplitude (AMo) (from 45,56±6,29% down to 39,04±8,64%, p=0,05) and the tension index (IT) (from 237,80±15,79 down to 145,9±60,81 s.u., p= 0,05).

The lipid spectrum of the blood was studied before and after the treatment. The study revealed a decrease in the levels of overall cholesterol (OC) and triglycerides (TG) in patients with initial hyperlipidemia (OC before the treatment was 6,4±1,02 and after the treatment - 5,67±0,59 mmol/L, p= 0,05; TG before the treatment was 2,73±0,0 and after the treatment - 2,18±0,23 mmol/L, p= 0,05). The study revealed a decrease in the level of fibrinogen from 3,57±0,13 down to 3,33±0,11 g/L (p<0,005).

The Efficacy of Treating Patients with Eh Using Sulfurated Hydrogen Balneo- and Peloidotherapy over a Period of 14 Days (2nd Group). Before the treatment, the majority of patients complained of headache and seeing blinking "spots" before one's eyes, which occurs with an increase in AP. After the treatment, there were no more complaints. There were no hypertensive crises during the treatment. The level of anxiety was assessed based on the results of the Spielberger Questionnaire. The study revealed no verifiable changes in indicators after the treatment.

According to APDM data, the 2nd group, just like the 1st group, demonstrated a verifiable decrease in the level of AP in the patients with first- and second-degree AH. In the daytime, SAP in the patients with first-degree AH verifiably diminished on average by 7.0 mm Hg (p=0,0013) and in those with second-degree AH - by 8,2 mm Hg (p=0,00026). The average level of SAP in the nighttime in the patients with first-degree AH diminished by 11,0 mm Hg (p=0,000219) and in those with second-degree AH - by 6,1 mm Hg (p=0,049). The average level of DAP in the patients with first-degree AH in the daytime diminished by 4,6 mm Hg (p=0,08); in the nighttime, a verifiable decrease in this indicator by 6,6 mm Hg (p=0,00004) was observed. In the patients with second-degree AH, DAP in the daytime diminished by 11,5 mm Hg (p=0,008); in the nighttime – by 14,0 mm Hg (p=0,003). The study investigated changes in indicators of blood pressure load. The dynamic of the TI was as follows: the study revealed a trend towards a decrease in this indicator after 24 hours in the patients with first-degree AH by 5,6 % (p=0,09), while in those with second-degree AH, this indicator verifiably diminished by 14,6% (p=0,02).

The TI of SAP in the daytime in the patients with first-degree AH diminished by 6,6% (p=0,01) and in those with second-degree AH – by 13,4% (p=0,015). In the nighttime, this indicator in the patients with first-degree AH diminished by 2,7% (p=0,04) and in those with second-degree AH – by 43,4% (p=0,007). The TI of DAP after 24 hours in the patients with first-degree AH

diminished by 11,2% (p=0,005) and in those with second-degree AH – by 18,6% (p=0,047). The TI of DAP in the daytime in the patients with first-degree AH diminished by 14,3 % (p=0,014) and in those with second-degree AH – by 27,1% (p=0,029). In the nighttime, this indicator in patients with first-degree AH diminished by 8,9±4,2% (p=0,02), while there was observed just a trend towards reduction in the patients with second-degree AH.

After 24 hours, the SI of SAP diminished in the patients with first-degree AH by 22,6 ±16,2 mm^2 (p=0,016) and in those with second-degree AH - by 108,3 ±110,2 mm^2 (p=0,008). In the daytime, this indicator verifiably diminished in the patients with first-degree AH by 21,98 ±18,2 mm^2 (p=0,021) and in those with second-degree AH - by 71,63 ±109,2 mm^2 (p=0,002). In the nighttime, there was observed just a trend towards reduction in the SI of DAP both in the patients with first-degree AH and those with second-degree AH.

The diurnal rhythm of AP was assessed via determining the DI. As a result of the treatment, the patients with initial disruption of the diurnal rhythm of SAP and DAP of the "non-dipper" and "night-peaker" type demonstrated positive changes in this indicator. In the "dipper" group, before and after the treatment the DI did not exceed the established norm.

The patients received diurnal electrocardiographic monitoring (ECGDM). The patients with first-degree AH in the daytime demonstrated a decrease in the heart rate, while in the nighttime no substantial changes in this indicator were detected. The patients with second-degree AH demonstrated a verifiable decrease in the heart rate both in the daytime and nighttime. After the treatment, there was observed no decrease in the number of solitary ventricular and supraventricular extrasystoles.

The analysis of the EchoCG in the patients with EH who underwent balneo-mud therapy over a period of 14 days revealed some increase in the systolic index in the patients with the eukinetic type of blood circulation; note that it did not exceed the established norm. Diastolic function did not change during the treatment process. The overall peripheral vascular resistance (OPVR) in this study group diminished (from 2151,05 down to 1651,3 $dyn/sec/cm^2$, p=0,04). Before the treatment, in conducting reactive hyperemia testing using the methodology by D. Celemajer *et al*., all the patients with EH demonstrated endothelial dysfunction. After the treatment, an increase in the diameter of the shoulder artery was observed (before the treatment - 3,1±2,2 and after the treatment - 4,0±2,6 % (p=0,05).

To assess the state of the ANS, CIG and ECGDM were conducted before and after the treatment. As a result of the treatment, a decrease in the tension index (p<0,05) was observed. Diurnal ECG monitoring data revealed an increase in pNN50 and a trend towards a decrease in LF and HF, which attests to a decrease in sympathicotonia and an increase in parasympathetic influences. Orthostasis testing revealed a decrease in autonomous reactivity.

The study investigated some indicators of lipid exchange in dynamic conditions (OC, TG, LDL, HDL). These indicators were studied separately in the patients with initial dyslipidemia and without it. No substantial changes in indicators of lipid exchange were detected in the patients with no initial dyslipidemia. The patients with hyperlipidemia had some decrease in overall cholesterol (OC before the treatment - 6.71± 1.55 and after the treatment - 6.12±1.60 mmol/L, p=0,026; TG – before the treatment -1.63±0.11 and after the treatment - 1.12±0,13 mmol/L, p=0,024).

The study investigated some indicators of hemostasis: the international normalized ratio (INR), hemolysate-induced platelet aggregation (HAT) and the concentration of fibrinogen in the blood. The study revealed an increase in the INR in the patients with both first- and second-degree AH. There was a decrease in the level of fibrinogen only in the patients with first-degree AH. The indicators of platelet aggregation did not change.

The Efficacy of Treating Patients with EH Using Sulfurated Hydrogen Balneo- and Peloidotherapy and Local Magnetotherapy over a Period of 14 Days (3rd Group). Complaints of headache and seeing blinking "spots" before one's eyes, which occurs with an increase in AP, were made by 36 patients. After the treatment, no complaints that can be related to increase AP were registered. The level of anxiety was assessed based on the results of the Spielberger Questionnaire. The average score on the personal anxiety scale before the treatment was 1,90±0,17 and after the treatment - 1,78±0,17 points (p=0,003).

The APDM data revealed that the level of AP verifiably diminished in both the patients with first- and those with second-degree AH. SAP in the daytime in the patients with first-degree AH diminished by 9,4±5,3 mm Hg (p=0,00002) and in those with second-degree AH - by 22,9±4,9 mm Hg (p=0,000004). The average level of SAP in the nighttime in the patients with first-degree AH diminished by 12,5±7,9 mm Hg (p=0,000007) and in those with second-degree AH by 19,5±4,8 mm Hg (p=0,00008).

The average level of DAP in the patients was distributed as follows: in the patients with first-degree AH, in the daytime this indicator diminished by 5,0±2.3 mm Hg (p=0,000049) and in the nighttime - by 8,2±5,4 mm Hg (p=0,003). In the patients with second-degree AH, DAP in the daytime diminished by 11,6±5,8 mm Hg (p=0,00) and in the nighttime – by 15,4±8,2 mm Hg (p=0,000008). The TI of SAP in the daytime in the patients with first-degree AH diminished by 31,32±12,34% (p=0,004) and in those with second-degree AH – by 31,91±15,56% (p=0,01). In the nighttime, this indicator in the patients with first-degree AH diminished by 57,07±22,34% (p=0,024) and in those with second-degree AH – by 55,08±32,12% (p=0,01). The TI of DAP in the daytime in the patients with first-degree AH diminished by 29,37±12,23% (p=0,005) and in those with second-degree AH – by 48,30±24,64% (p=0,00). In the nighttime, this indicator in the patients with first-degree AH diminished by 50,65±32,84% (p=0,012) and in those with second-degree AH – by 47,78±22,23% (p=0,07).

In the daytime, the SI of SAP in the patients with first-degree AH diminished by 28,5±12,34 mm² (p=0,028) and in those with second-degree AH - by 85,8±32,56 mm² (p=0,045). In the nighttime, the patients with first-degree AH demonstrated a decrease in the SI of SAP by 48,1±14,54 mm² (p=0,038), those with second-degree AH – by 55,9±34,45 mm² (p=0,01). In the daytime, the SI of DAP verifiably diminished in the patients with first-degree AH by 29,57±13,21 mm² (p=0,021) and in those with second-degree AH - by 88,78±41,32 mm² (p=0,00). In the nighttime, there was observed a trend towards a decrease in the level of the SI of DAP in the patients with first-degree AH by 45,78±23,12 mm² (p=0,110). The level of the SI of DAP in the nighttime in the patients with second-degree AH verifiably diminished by 143,00±56,85 mm² (p=0,022).

The DI was determined in all the patients. The patients with disruption of the diurnal rhythm of AP of the "night-peaker" and "non-dipper" type, according to the APDM data, demonstrated an increase in the DI of SAP from 6,17±2,32 up to 11,92±3,98 (p=0,037) and in the DI of DAP – from 0,4±4,92 up to 17,99 (p=0,000). The patients with a normal diurnal rhythm demonstrated no changes in the diurnal rhythm. Two patients with the DI of DAP of the "over-dipper" type, whose SI was 35,5±9,19, demonstrated its decrease down to 6,0±8,48, i.e. such patients had some increase in DAP in the nighttime.

ECGDM was conducted. After the treatment, all the patients demonstrated sinus rhythm. The patients with second-degree demonstrated a verifiable decrease in the heart rate in the daytime from 87,25±11,87 down to

72,50±3,69 (p=0,044) and from 74,67±10,5 down to 59,67±4,16 in the nighttime (p=0,05). The number of extrasystoles did not change substantially after the treatment.

During the treatment, the patients with different types of blood circulation based on EchoCG data were examined for indicators of hemodynamics and systolic and diastolic myocardial function. The patients with eukinesis demonstrated no changes in indicators of central hemodynamics. With the hyperkinetic type of blood circulation, there was observed a decrease in the systolic index and an increase in the E/A ratio, which attests to changes in hemodynamics towards eukinesis and an improvement in diastolic function. The patients with the hypokinetic type of blood circulation demonstrated an increase in EF during the treatment.

Before the treatment, all the patients with EH had demonstrated endothelial dysfunction. After the treatment, endothelial function considerably improved: there was observed an increase in endothelium-dependent vasodilation (EDVD) of the shoulder artery from 2,64±0,7% up to 4,6±2,1% (p=0,00).

In studying the mean indicators of the temporal analysis of the variability of the heart rhythm based on diurnal ECG monitoring data, there was revealed an increase in such indicators as pNN50 and ÍF and a decrease in LF, which attests to a sympatholitic effect and an increase in parasympathetic influences. As a result of the treatment, there was observed a decrease in the levels of OC, the INR and HPA.

Discussion of Results Obtained: The study comparatively assessed the efficacy of a course of balneopeloidotherapy for EH shortened down to 14 days and a regular course of balneo-mud therapy spanning 21 days. In studying the dynamics of complaints, no substantial differences between the groups were recorded. The tempo of the hypotensive effect arising based on office AP data was the same as well; note that the level of SAP in both groups diminished and stabilized by the 4th day of the treatment and that of DAP – by the 4-5th day. For more accurate assessment of the hypotensive effect, APDM indicators were used. To assess the markedness of the hypotensive effect in the groups, the study analyzed the differences by the Δ indicator – the difference between the level of AP before and after the treatment (the table). In the daytime, the more significant decrease in SAP and DAP was recorded in the 1st study group. In the nighttime, a decrease in the 1st group was more significant as well, while a decrease in DAP in both groups was comparable. The target level of

AP in the 1st group was attained in 90% of the patients, in the 2nd – in 80%. The more marked decrease of the TI of SAP and TI of DAP was recorded in the patients of the 1st group. The 2nd group demonstrated a worsening in the dynamics of the TI under the shortened course of treatment; in the nighttime, this group did not demonstrate a positive dynamic of the TI of DAP.

In both groups with a normal rhythm of AP, the diurnal index after the treatment stayed within the normal limits. In the patients with insufficient reduction in AP in the nighttime ("non-dipper"), the DI normalized after the treatment and in those with disruption of the diurnal rhythm by the "nigh-peaker" type it increased but did not reach the optimal values.

Both groups were investigated for changes in ECGDM indicators. The study revealed a verifiable decrease in the heart rate in the daytime and nighttime; no verifiable differences between the groups were recorded. After the treatment, the 1st group demonstrated a decrease in the number of solitary atrial and ventricular extrasystoles. The 2nd group demonstrated no substantial changes in initial indicators.

In the assessment of indicators of the heart's functional state based on EchoCG data, the 1st group demonstrated an increase in the Å/À indicator and some increase in EF, which attests to an improvement in both the diastolic and systolic function of the left ventricle. The 2nd group demonstrated no changes in these indicators. Reactive hyperemia testing using the methodology by D. Celemajer et al. revealed the more marked increase in the diameter of the shoulder artery in the 1st group. The study investigated the impact of resort factors on the ANS. Both groups demonstrated a decrease in sympathetic and an increase in parasympathetic influences. The assessment of the level of OC before and after the treatment revealed a verifiable decrease in OC only in the 1st study group.

The study conducted a comparative assessment of the efficacy of shortened courses of balneopeloidotherapy with the inclusion of magnetotherapy and without (the 2nd and 3rd study groups).

The assessment of complaints on a 3-point scale revealed no significant differences between the 2nd and 3rd groups. The levels of personal and situational anxiety based on Spielberger Questionnaire data more significantly diminished in the 3rd group.

The inclusion of VMFMP in the course of treatment ensured a quicker emergence of the hypotensive effect. In this regard, the 2nd group demonstrated a decrease and stabilization in office SAP and DAP by the 4th day of

treatment and the 3rd group – on the 2nd day. The 3rd study group demonstrated the more marked dynamic of SAP both in the daytime and nighttime. No differences in reduction in DAP between the groups were detected. In the nighttime, DAP more significantly increased in the 3rd study group. The study examined indicators of pressure load. The TI and SI of SAP diminished both in the 2nd and 3rd study groups. The TI of DAP in the nighttime more markedly diminished in the 3rd group. No differences in reduction in the TI of DAP between the groups were detected. Target AP in the 2nd group was attained in 80% of the patients and in the 3rd group - in 90%. The study groups were examined for the diurnal rhythm of AP and its dynamics. In the patients with a normal diurnal profile of AP, the TI stayed within the normal limits. Both the non-dippers and night-peakers demonstrated an increase in the DI of SAP. The DI of DAP in the 2nd group's non-dippers reached the normal values and the night-peakers demonstrated an increase in it, which did not reach the norm. In the 3rd group, the DI of DAP normalized both in the non-dippers and night-peakers. Both groups demonstrated a decrease in the heart rate in the daytime and nighttime. The more marked decrease in the heart rate was recorded in the 3rd study group.

The study conducted an analysis of the dynamic of the EchoCG indicators depending on the initial type of hemodynamics. The more marked normalizing effect was recorded in the 3rd study group. In those with the hyperkinetic type of blood circulation, the minute volume (MV) and DI diminished down to the established norm; the E/A indicator, which reflects diastolic myocardial function, increased and came close to the norm after the treatment. No changes in the 2nd group were recorded. The patients with the hypokinetic type of blood circulation in the 3rd group demonstrated an increase in EF, with the norm's upper limit reached.

Both study groups demonstrated an increase in the diameter of the shoulder artery in conducting reactive hyperemia testing after the treatment. The 3rd group demonstrated the more marked increase in the diameter of the shoulder artery compared with the 2nd study group.

The examination of the indicators of Holter ECG monitoring (ECGHM) and CIG, which reflect the autonomous status, revealed in both groups an increase in parasympathetic and a decrease in sympathetic influences. The comparative assessment of the effects revealed the more marked changes in ANS indicators in the 3rd study group.

The groups demonstrated no verifiable changes in indicators of lipid exchange, the INR and fibrinogen.

An increase in the level of HPA was recorded only in the 3rd study group, which points to the hypo-aggregation effect of magnetotherapy.

CONCLUSION

Thus, the more marked healing effect of spa treatment has been recorded under the course of balneopeloidotherapy spanning 21 days. Under this type of treatment, the study has recorded the hypotensive, hypolipidemic and sympatholitic effects and an improvement in indicators of the diurnal rhythm of AP, central hemodynamics and endothelial function. Shortening the course of treatment down to 14 days somewhat diminishes the markedness of the hypotensive effect. The inclusion of magnetopuncture in the course of treatment leads to optimization of the results of spa treatment: there are a marked and rapid decrease in the level of AP, normalization of its diurnal rhythm, a substantial decrease in anxiety and the activity of the sympathetic division of the ANS. This is accompanied by a decrease in the heart rate, an improvement in diastolic myocardial function and a decrease in endothelial dysfunction and platelet aggregation.

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