REVIEW ARTICLE

Arterial Hypertension in Children and Adolescents

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SUMMARY

Seeman T.: Arterial Hypertension in Children and Adolescents
Hypertension is one of the main risk factors for cardiovascular diseases. Hypertension in childhood is defined as blood pressure 95. percentile for healthy children population. The prevalence of hypertension in childhood is considerably lower than in adults and is about 1%. The aetiology of hypertension in childhood differs from the adult population – in children secondary forms are more common than primary; however, in adolescents the primary form prevails. In general, the younger the child and the higher the blood pressure, the more probably it is the secondary form of hypertension. The most common causes of secondary hypertension are renal diseases (renoparenchymal or renovascular). Cardiac diseases (aortic isthmus stenosis), endocrinopathies, central nervous system disorders or use of hypertensinogenic drugs are less frequent causes of secondary hypertension. Each child with hypertension has to be carefully examined; the extent of the examination depends on the age of the child and severity of hypertension. The main task for the investigation is to exclude or reveal a secondary form of hypertension which could be causally treated (i.e. angioplasty in renal artery stenosis). Treatment of hypertension can be both non-pharmacological and pharmacological (angiotensin-converting enzyme inhibitors, beta-blockers, calcium channel blockers, diuretics, angiotensin receptor blockers).
Key words: arterial hypertension, blood pressure. *Se.*

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Hypertension is one of the main risk factors of cardiovascular disorders, the principal cause of death in adulthood. Treatment of hypertension may reduce the incidence of cardiovascular events as well as cardiovascular death rates. The prevalence of hypertension in the adult population in the Czech Republic is about 35 % (1, 2). Childhood hypertension is also associated with increased cardiovascular morbidity rates in the general population and with increased mortality rates in chronically ill child population, e.g. with chronic renal failure. Hypertension in childhood is much rarer than in adulthood; its prevalence is about 1 % (3).

Increased blood pressure (BP) in childhood is usually diagnosed during preventive pediatric check-up visits. Upon interpretation of the measured blood pressure values, it must be considered that the BP value increases with age in childhood and differs in boys and girls. Therefore the measured BP values must be assessed according to a child's sex, age and height. The BP values in childhood are interpreted on percentile graphs based on data collected from BP measurements in a population including thousands of healthy children (3). The "Report of the Second Task Force " percentile graphs, created by the American Working Group on Hypertension in Childhood in 1987, are the most commonly used percentile graphs worldwide. Since 1996 the graphs have been included in the Health and Vaccination Certificate which is issued to all newborns at maternity hospitals in the Czech Republic. The work was updated in 1996 ("Update on the 1987 Task Force Report") and then in 2004 ("Fourth Report"). Results in these update reports are presented in tables instead of percentile graphs. (Tab. 1, 2). The tables evaluate the BP values according to a child's sex and age, as well as his/her height. (4, 5).

Pediatric hypertension has been defined as BP 95th percentile, considering sex, age and height, measured on 3 different occasions. BP values within the 90th–95th percentile region are defined as high normal BP (or prehypertension), while BP values 90th percentile are considered normal BP. The "Fourth Report" added 50th and 99th percentile values in the normative tables. (Tab. 1, 2).

This report follows recommendations for classification of hypertension in adulthood and classifies paediatric hypertension in the following manner: grade 1 hypertension (BP between 95th percentile and 5 mmHg above 99th percentile) and grade 2 (BP more than 5 mmHg above 99th percentile).

MEASURING BP

BP should be measured from the age of 3 onwards, on every preventive pediatric visit, i.e. every other year, or when symptoms potentially caused by hypertension – such as headache or epistaxis – are present.

BP must be measured under standard conditions (4, 5). The auscultation technique remains the recommended method for BP measurement, and the mercury sphygmomanometer remains a standard – with the exception of infants, where oscilometric devices are recommended. The choice of the correct size cuff is based on the child's arm circumference (rather than its arm length, as recommended up to 1996) – the cuff width must be about 40 % of the arm circumference, while the cuff must be long enough to cover 80–100 % of the arm circumference. In practice, 3 cuff sizes are used in children – child-sized, adult-sized and wide (large) adult-sized cuffs (Tab. 3). As a standard, the BP should be measured on the right arm. When increased BP values are measured, the BP

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Table 1. BP values in boys according to age and height

Age in years	BP percentile	Systolic BP mm Hg Height Percentile							Diastolic BP mm Hg Height Percentil						
		5.	10.	25.	50.	75.	90.	95.	5.	10.	25.	50.	75.	90.	95.
1	50.	80	81	83	85	87	88	89	34	35	36	37	38	39	39
	90.	94	95	97	99	100	102	103	49	50	51	52	53	53	54
	95.	98	99	101	103	104	106	106	54	54	55	56	57	58	58
	99.	105	106	108	110	112	113	114	61	62	63	64	65	66	66
2	50.	84	85	87	88	90	92	92	39	40	41	42	43	44	44
	90.	97	99	100	102	104	105	106	54	55	56	57	58	58	59
	95.	101	102	104	106	108	109	110	59	59	60	61	62	63	63
	99t.	109	110	111	113	115	117	117	66	67	68	69	70	71	71
3	50.	86	87	89	91	93	94	95	44	44	45	46	47	48	48
	90.	100	101	103	105	107	108	109	59	59	60	61	62	63	63
	95.	104	105	107	109	110	112	113	63	63	64	65	66	67	67
	99.	111	112	114	116	118	119	120	71	71	72	73	74	75	75
4	50.	88	89	91	93	95	96	97	47	48	49	50	51	51	52
	90.	102	103	105	107	109	110	111	62	63	64	65	66	66	67
	95.	106	107	109	111	112	114	115	66	67	68	69	70	71	71
	99.	113	114	116	118	120	121	122	74	75	76	77	78	78	79
5	50.	90	91	93	95	96	98	98	50	51	52	53	54	55	55
	90.	104	105	106	108	110	111	112	65	66	67	68	69	69	70
	95.	108	109	110	112	114	115	116	69	70	71	72	73	74	74
	99.	115	116	118	120	121	123	123	77	78	79	80	81	81	82
6	50.	91	92	94	96	98	99	100	53	53	54	55	56	57	57
	90.	105	106	108	110	111	113	113	68	68	69	70	71	72	72
	95.	109	110	112	114	115	117	117	72	72	73	74	75	76	76
	99.	116	117	119	121	123	124	125	80	80	81	82	83	84	84
7	50.	92	94	95	97	99	100	101	55	55	56	57	58	59	59
	90.	106	107	109	111	113	114	115	70	70	71	72	73	74	74
	95.	110	111	113	115	117	118	119	74	74	75	76	77	78	78
	99.	117	118	120	122	124	125	126	82	82	83	84	85	86	86
8	50.	94	95	97	99	100	102	102	56	57	58	59	60	60	61
	90.	107	109	110	112	114	115	116	71	72	72	73	74	75	76
	95.	111	112	114	116	118	119	120	75	76	77	78	79	79	80
	99.	119	120	122	123	125	127	127	83	84	85	86	87	87	88
9	50.	95	96	98	100	102	103	104	57	58	59	60	61	61	62
	90.	109	110	112	114	115	117	118	72	73	74	75	76	76	77
	95.	113	114	116	118	119	121	121	76	77	78	79	80	81	81
	99.	120	121	123	125	127	128	129	84	85	86	87	88	88	89
10	50.	97	98	100	102	103	105	106	58	59	60	61	61	62	63
	90.	111	112	114	115	117	119	119	73	73	74	75	76	77	78
	95.	115	116	117	119	121	122	123	77	78	79	80	81	81	82
	99.	122	123	125	127	128	130	130	85	86	86	88	88	89	90
11	50.	99	100	102	104	105	107	107	59	59	60	61	62	63	63
	90.	113	114	115	117	119	120	121	74	74	75	76	77	78	78
	95.	117	118	119	121	123	124	125	78	78	79	80	81	82	82
	99.	124	125	127	129	130	132	132	86	86	87	88	89	90	90
12	50.	101	102	104	106	108	109	110	59	60	61	62	63	63	64
	90.	115	116	118	120	121	123	123	74	75	75	76	77	78	79
	95.	119	120	122	123	125	127	127	78	79	80	81	82	82	83
	99.	126	127	129	131	133	134	135	86	87	88	89	90	90	91
13	50.	104	105	106	108	110	111	112	60	60	61	62	63	64	64
	90.	117	118	120	122	124	125	126	75	75	76	77	78	79	79
	95.	121	122	124	126	128	129	130	79	79	80	81	82	83	83
	99.	128	130	131	133	135	136	137	87	87	88	89	90	91	91
14	50.	106	107	109	111	113	114	115	60	61	62	63	64	65	65
	90.	120	121	123	125	126	128	128	75	76	77	78	79	79	80
	95.	124	125	127	128	130	132	132	80	80	81	82	83	84	84
	99.	131	132	134	136	138	139	140	87	88	89	90	91	92	92
15	50.	109	110	112	113	115	117	117	61	62	63	64	65	66	66
	90.	122	124	125	127	129	130	131	76	77	78	79	80	80	81
	95.	126	127	129	131	133	134	135	81	81	82	83	84	85	85
	99.	134	135	136	138	140	142	142	88	89	90	91	92	93	93
16	50.	111	112	114	116	118	119	120	63	63	64	65	66	67	67
	90.	125	126	128	130	131	133	134	78	78	79	80	81	82	82
	95.	129	130	132	134	135	137	137	82	83	83	84	85	86	87
	99.	136	137	139	141	143	144	145	90	90	91	92	93	94	94
17	50.	114	115	116	118	120	121	122	65	66	66	67	68	69	70
	90.	127	128	130	132	134	135	136	80	80	81	82	83	84	84
	95.	131	132	134	136	138	139	140	84	85	86	87	87	88	89
	99.	139	140	141	143	145	146	147	92	93	93	94	95	96	97

Table 2. BP values in girls according to age and height

Age in years	BP percentile	Systolic BP mm Hg Height Percentile							Diastolic BP mm Hg Height Percentile						
		5.	10.	25.	50.	75.	90.	95.	5.	10.	25.	50.	75.	90.	95.
1	50.	80	81	83	85	87	88	89	34	35	36	37	38	39	39
	90.	94	95	97	99	100	102	103	49	50	51	52	53	53	54
	95.	98	99	101	103	104	106	106	54	54	55	56	57	58	58
	99.	105	106	108	110	112	113	114	61	62	63	64	65	66	66
2	50.	84	85	87	88	90	92	92	39	40	41	42	43	44	44
	90.	97	99	100	102	104	105	106	54	55	56	57	58	58	59
	95.	101	102	104	106	108	109	110	59	59	60	61	62	63	63
	99.	109	110	111	113	115	117	117	66	67	68	69	70	71	71
3	50.	86	87	89	91	93	94	95	44	44	45	46	47	48	48
	90.	100	101	103	105	107	108	109	59	59	60	61	62	63	63
	95.	104	105	107	109	110	112	113	63	63	64	65	66	67	67
	99.	111	112	114	116	118	119	120	71	71	72	73	74	75	75
4	50.	88	89	91	93	95	96	97	47	48	49	50	51	51	52
	90.	102	103	105	107	109	110	111	62	63	64	65	66	66	67
	95.	106	107	109	111	112	114	115	66	67	68	69	70	71	71
	99.	113	114	116	118	120	121	122	74	75	76	77	78	78	79
5	50.	90	91	93	95	96	98	98	50	51	52	53	54	55	55
	90.	104	105	106	108	110	111	112	65	66	67	68	69	69	70
	95.	108	109	110	112	114	115	116	69	70	71	72	73	74	74
	99.	115	116	118	120	121	123	123	77	78	79	80	81	81	82
6	50.	91	92	94	96	98	99	100	53	53	54	55	56	57	57
	90.	105	106	108	110	111	113	113	68	68	69	70	71	72	72
	95.	109	110	112	114	115	117	117	72	72	73	74	75	76	76
	99.	116	117	119	121	123	124	125	80	80	81	82	83	84	84
7	50.	92	94	95	97	99	100	101	55	55	56	57	58	59	59
	90.	106	107	109	111	113	114	115	70	70	71	72	73	74	74
	95.	110	111	113	115	117	118	119	74	74	75	76	77	78	78
	99.	117	118	120	122	124	125	126	82	82	83	84	85	86	86
8	50.	94	95	97	99	100	102	102	56	57	58	59	60	60	61
	90.	107	109	110	112	114	115	116	71	72	72	73	74	75	76
	95.	111	112	114	116	118	119	120	75	76	77	78	79	79	80
	99.	119	120	122	123	125	127	127	83	84	85	86	87	87	88
9	50.	95	96	98	100	102	103	104	57	58	59	60	61	61	62
	90.	109	110	112	114	115	117	118	72	73	74	75	76	76	77
	95.	113	114	116	118	119	121	121	76	77	78	79	80	81	81
	99.	120	121	123	125	127	128	129	84	85	86	87	88	88	89
10	50.	97	98	100	102	103	105	106	58	59	60	61	61	62	63
	90.	111	112	114	115	117	119	119	73	73	74	75	76	77	78
	95.	115	116	117	119	121	122	123	77	78	79	80	81	81	82
	99.	122	123	125	127	128	130	130	85	86	86	88	88	89	90
11	50.	99	100	102	104	105	107	107	59	59	60	61	62	63	63
	90.	113	114	115	117	119	120	121	74	74	75	76	77	78	78
	95.	117	118	119	121	123	124	125	78	78	79	80	81	82	82
	99.	124	125	127	129	130	132	132	86	86	87	88	89	90	90
12	50.	101	102	104	106	108	109	110	59	60	61	62	63	63	64
	90.	115	116	118	120	121	123	123	74	75	75	76	77	78	79
	95.	119	120	122	123	125	127	127	78	79	80	81	82	82	83
	99.	126	127	129	131	133	134	135	86	87	88	89	90	90	91
13	50.	104	105	106	108	110	111	112	60	60	61	62	63	64	64
	90.	117	118	120	122	124	125	126	75	75	76	77	78	79	79
	95.	121	122	124	126	128	129	130	79	79	80	81	82	83	83
	99.	128	130	131	133	135	136	137	87	87	88	89	90	91	91
14	50.	106	107	109	111	113	114	115	60	61	62	63	64	65	65
	90.	120	121	123	125	126	128	128	75	76	77	78	79	79	80
	95.	124	125	127	128	130	132	132	80	80	81	82	83	84	84
	99.	131	132	134	136	138	139	140	87	88	89	90	91	92	92
15	50.	109	110	112	113	115	117	117	61	62	63	64	65	66	66
	90.	122	124	125	127	129	130	131	76	77	78	79	80	80	81
	95.	126	127	129	131	133	134	135	81	81	82	83	84	85	85
	99.	134	135	136	138	140	142	142	88	89	90	91	92	93	93
16	50.	111	112	114	116	118	119	120	63	63	64	65	66	67	67
	90.	125	126	128	130	131	133	134	78	78	79	80	81	82	82
	95.	129	130	132	134	135	137	137	82	83	83	84	85	86	87
	99.	136	137	139	141	143	144	145	90	90	91	92	93	94	94
17	50.	114	115	116	118	120	121	122	65	66	66	67	68	69	70
	90.	127	128	130	132	134	135	136	80	80	81	82	83	84	84
	95.	131	132	134	136	138	139	140	84	85	86	87	87	88	89
	99.	139	140	141	143	145	146	147	92	93	93	94	95	96	97

must be measured on the left arm at least once, and on lower extremities as well, to rule out coarctation of the aorta. As a standard, the BP is measured in a sitting position, 3–5 minutes after calming the child down. The arm must be relaxed and supported, and the cubital region, where auscultation is performed, must be at heart level. A stetoscope should be placed over the brachial artery, a few centimetres distal to the cuff's lower edge, i.e. it must not touch the cuff.

The cuff should be inflated 20–30 mm Hg above the expected systolic BP value and deflated at a slow rate: about 2–3 mm Hg/second. The systolic BP is recorded when the heart sound is first heard (Korotkov's first sound signal), the diastolic BP is recorded at the point when the sounds disappear completely (Korotkov's fifth sound signal) in children of all age groups (previously, Korotkov's fourth sound signal was recommended in children younger than 12 years of age).

As with the adult population, the BP in children may be monitored either occasionally during check-up visits ("casual blood pressure"), as well as at home ("home blood pressure") or may be monitored over 24 hours ("ambulatory blood pressure monitoring"

Table 3. Cuff choice for BP monitoring

Cuffs	Arm circumference	Cuff width (40 % of the arm circumference)
newborn	7–13 cm	4 cm
infant	12–20 cm	6 cm
child/pediatric	17–26 cm	9 cm
adult	24–32 cm	12 cm
adult large	32–42 cm	15 cm
adult thigh cuff	41–45 cm	19 cm

– ABPM). In the last ten years ABPM has become a valued method for diagnostics and treatment of pediatric hypertension. It helps to diagnose "white coat hypertension" (occurring in about 30 % of children with elevated casual blood pressure), as well as providing information on circadian rhythm of BP and facilitates to differentiate between primary and secondary hypertension, based on night BP values and the night BP dip (6–8). The primary indications for ABPM include: suspected "white coat hypertension" or nighttime hypertension. Every hospital should have access to ABPM. ABPM results should always be assessed by a physician with sound knowledge of the pediatric hypertension, in order to avoid misinterpretation of the measured values.

ETIOLOGY OF PEDIATRIC HYPERTENSION

In child population, mainly in younger age groups (infants, toddlers and pre-school children), secondary forms of hypertension are more frequent than primary/essential hypertension.

Therefore primary/essential hypertension can be diagnosed only when secondary hypertension is ruled out. The rate of primary hypertension related to the total incidence of hypertension increases with age in children. In general, the younger the child and the more severe the hypertension, the more likely it is to be secondary form of hypertension. On the contrary, the older the child (mainly adolescents), the more likely it is to be the primary form of hypertension.

Secondary hypertension is not a disorder but only a secondary sign of a specific organ diseaser (e.g. kidney, heart or endocrine glands – renal, cardiac, endocrine hypertension). The most common form of secondary HT is renoparenchymatous hypertension (60–80 % of secondary forms). Disorders affecting renal parenchyma and resulting in hypertension, include mainly glomerulonephritis, reflux nephropathy, obstructive uropathy, acute and chronic renal failure, polycystic renal disease, multicystic kidney dysplasia.

Renovascular hypertension, mostly resulting from stenosis of secondary or tertiary branches of the renal artery, caused mainly by fibromuscular dysplasia, is the second most common cause (about 5 %) of secondary hypertension in children.

Cardiovascular causes of hypertension include coarctation of the aorta (1–5 %), rarely arterio-venous fistules or persistent ductus Botali. Isolated coarctation of the aorta with the ductus Botali closed is clinically asymptomatic in childhood and is usually detected accidentally. 1–5 % of secondary hypertensions result form endocrine disorders, most frequently dysfunctions of adrenomedullary or adrenocortical hormones (pheochromocytoma, Cushing's syndrome, primary hyperaldosteronism or pseudohyperaldosteronism, rare hypertensive forms of adrenogenital syndrome – congenital adrenal hyperplasia) and the thyroid (hyperthyroidism or hypothyroidism). Neurological causes of hypertension include mainly expansive or posttraumatic lesions in the central nervous system, predominantly those associated with intracranial hypertension. Other rare causes of hypertension include medication-induced hypertension (hormonal contraceptives, anabolic hormones, cyclosporin, tacrolimus, psychostimulating medications, as well as various abused substances). Prevalence of individual forms of hypertension varies with a child's age; therefore, the most common causes of hypertension in Table 4 are presented according to age categories.

SYMPTOMATOLOGY OF PEDIATRIC HYPERTENSION

Hypertension in children may be asymptomatic (mostly in older children and adolescents with grade 1 hypertension) and is most often diagnosed on preventive pediatric visits. Symptoms of hypertension appear mostly in children with more severe forms of hypertension, and they usually include headaches, epistaxis, tiredness or excessive perspiration. Newborn and infant hypertension is nearly always asymptomatic; the symptoms are unspecific, more serious and may be life-threatening (restlessness, increased irritability, failure to thrive, cyanosis, acute respiratory syndrome, cramps or even heart failure). When any of the above symptoms occur, the child's BP should be monitored.

Table 4. Commonest caused of hypertension in individual children age groups

Child's age group	3 commonest causes of hypertension
Newborns and infants	Thrombosis of the renal artery or vein Congenital kidney disorder Coarctation of the aorta
Pre-school children (1–6 years of age)	Renoparenchymatous Renovascular Coarctation of the aorta
Younger schoolchildren (6–10 years of age)	Renoparenchymatous Renovascular Primary
Older schoolchildren and adolescents (11–18 years of age)	Primary Renoparenchymatous Medicine-induced

EXAMINATION OF A HYPERTENSIVE CHILD

Examination of a child with hypertension has 4 aims (Fig. 1):

1. To confirm or rule out **persistent** elevation of BP and to determine **severity** of hypertension,
2. To detect or rule out any **secondary** form of hypertension,
3. To detect possible **target organ damage**,
4. To look for **other risk factors** of cardiovascular disorders and other serious diseases associated with hypertension.

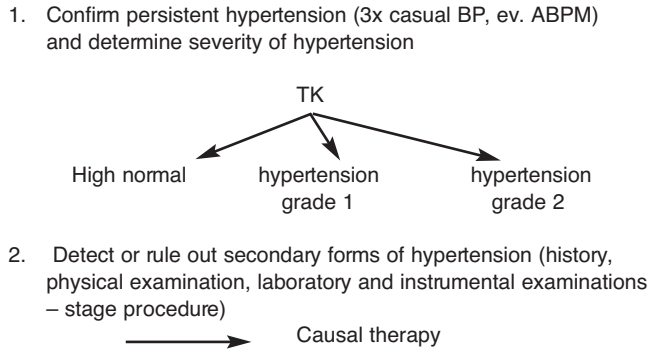

Figure 1. Algorithm of the examination procedure in a child with high blood pressure

1. Persistent elevation of BP can be confirmed either by repetitive measurement of the casual blood pressure (at least 3 measurements are required to diagnose hypertension), or by ABPM, which is indicated especially when "white coat hypertension" is suspected.

2. The scope of examinations aimed at detection of secondary forms of hypertension depends on the child's age and on the severity of his hypertension. Table 4 presents 3 most common causes of hypertension in individual age categories.

3. Examination detecting hypertonic target organ damages is focused on detection of the left ventricular hypertrophy (echocardiography is the method of choice) and hypertension-induced retinal angiopathy (fundoscopy).

4. Obesity, positive family history of hypertension or of cardiovascular morbidity or mortality, hyperlipidemia, insufficient physical activity and smoking are other cardiovascular risk factors which are most frequently enquired for.

In order to complete the above tasks, thorough past medical history and physical, laboratory and instrumental examinations must be performed.

Laboratory and instrumental examinations

The scope of examinations is varied and depends on a child's age and on the severity of his hypertension, as well as on positive findings in history or of any clinical symptoms, suggesting secondary hypertension. In general, the younger the child and the more serious his hypertension, the more thorough examination is required to detect the suspected secondary hypertension.

So-called "stage procedure" is applied. The first stage includes **basal examination**, which must be completed in all pediatric patients with confirmed hypertension, regardless of its severity or the child's age (Tab. 5).

In certain patients who are suspected from secondary forms of hypertenison, based on the BP measurements, child's age, history and physical examination or on the basal examination results, some of the **special examinations**, (such as renal scintigraphy, cystourethrography, Doppler examination of the renal arteries, ultrasound or CT examinations of the adrenals and abdomen, urinary excretion of electrolytes, proteins, catecholamine metabolites, plasma renin activity, aldosterone, cortisole, thyroid hormones) are performed at the second examination stage.

In patients highly suspected for particular forms of secondary hypertension, based on the BP measurement, the child's age, history, physical examination or on the 1st and 2nd stage examination results, further **targeted examinations** (e.g. renal angiography, scintigraphy with MIBG (meta-iodobenzylguanidine), extended serum steroid hormones spectrum or brain imaging) are performed at the third examination stage.

Table 5. 1st stage – basal - examination

Urine- chemistry and sediment
Complete blood count (CBC)
Serum electrolytes, urea, creatinine, uric acid
Triglycerides, total cholesterol, event. LDL-cholesterol, HDL--cholesterol
Renal ultrasound
Echocardiography, event. fundoscopy

TREATMENT OF HYPERTENSION

The treatment goal is to adjust the blood pressure – i.e. to reduce the blood pressure 95th percentile (in children with chronic renal disorder, diabetes or with affected target organs 90th percentile), as well as to prevent onset or to normalize existing hypertension-induced target organ damage (left ventricular hypertrophy, hypertension-induced retinal angiopathy or hypertension-induced nephroangiosclerosis), and to reduce cardiovascular morbidity and mortality associated with hypertension.

Causal therapy is feasible in most secondary forms of hypertension and is aimed at correcting the hypertension cause, e.g. dilation of the renal artery stenosis, nephrectomy of an afunctional kidney, removal of a pheochromocytoma or surgery on coarctation of the aorta.. Treatment of primary hypertension is focused on adjustment of the elevated BP as well as on management of the risk factors, affecting BP, such as obesity, lack of physical activity or incorrect dietary habits (high fat foods, energy dense and salty foods).

Treatment of hypertension may be non-pharmacological and pharmacological.

Non-pharmacological treatment

The treatment must be initiated in all children with hypertension (i.e. BP 95th percentile), as well as in all children with high normal BP (i.e. between 90th–95th percentile)!

Weight reduction

Body weight correlates with BP values and is one the principal determinants of BP or hypertension in children. Incidence of hypertension is higher in obese children than in non-obese. Weight reduction may result in reduction of both the systolic and diastolic BP in hypertensive adults as well as in hypertensive children. (9).

Reduction of salt intake

Current Fourth Report recommendations include reduction of salt intake in children between 4–8 years of age down to 3 grams of salt per day, in children older than 8 years of age to 3.7 grams per day. For adults it is recommended to reduce salt intake below 6 grams of salt per day (i.e. 100 mmol of natrium per day). Considering that most of the salt is taken in ready- made foods, it is necessary to primarily cut down on eating such high salt foods (e.g. fast food, sausages, instant soups).

Physical activity

Physical activity and physical condition is inversely proportional to BP values in adults and children. (10). Therefore improvement in physical condition reduces the BP. Dynamic activities are recommended (brisk walk, running, cycling, swimming) for 45 minutes at least three times a week.

Pharmacological treatment

Pharmacological treatment must be initiated in all pediatric hypertonic patients with symptomatic hypertension, with secondary hypertension, with hypertension affecting target organs, with type 1 and type 2 diabetes and in hypertension refractory to nonpharmacological treatment over a long period of time (cca 6–12 months).

A summary of the decision making process in indicating either form of hypertension therapy is presented on Figure 2 .

ANTIHYPERTENSIVE MEDICATION

Choice of medication

Based on the latest guidelines (5), 5 groups of anti-hypertensive drugs could be used in treatment of pediatric hypertension: 1) diuretics, 2) beta-blockers, 3) angiotensin-converting enzyme inhibitors (ACE-inhibitors), 4) calcium channels blockers, and recently also 5) angiotensin receptor blockers.

No efficacy and safety studies to compare different groups of drugs are available in pediatrics; therefore the choice of initial medication is left to an attending physician – anti-hypertensive drugs from any group may be used, with exception of some disorders where one group has been proved to be more efficient than other groups – e.g. ACE – inhibitors in renoparenchymatous hypertension, diabetes or microalbuminuria.

Anti-hypertensive treatment procedure

In the past so-called step procedure was used, when the therapy was initiated with a low dose of a single drug, and then in the next step the dose was increased up to the maximum dose, and after that the concomitant therapy with another drug was initiated. Currently, combined treatment strategy is used more often, when the concomitant medicine is added provided the recommended dose of the first antihypertensive drug is insufficient, while dosing of the first medication is not increased to the maximum dose. The advantage of this procedure is that it benefits from different mechanisms of the individual groups of drugs, while their combination in low doses suggests no substantial risk of side effects.

Table 6. Overview of main groups of anti-hypertensive agents

Group of medicine	Principal indication	Contraindication	Side effects
ACE-inhibitors and angiotensin receptor blockers	– renoparenchymatous HT primarily with proteinuria – renovascular hypertension (only unilateral and hemodynamically insignificant) – diabetic nephropathy – left ventricular hypertrophy or heart failure – primary high- renin HT	– bilateral renal artery stenosis or a solitary kidney renal artery stenosis – hyperkalemia	– non- productive (dry) irritable cough (only ACE-inhibitors) – hyperkalemia – acute renal failure
Beta-blockers	– hyperkinetic form of primary hypertension – high- renin form of primary hypertension – hyperthyroidism – feochromocytoma	– astma bronchiale – cardiac conductive dysfunctions – subjects with high physical activity	– bronchoconstriction – bradycardia – reduction of physical capacity – sexual dysfunctions – dyslipidemias – hypoglycemia – cold extremities
Calcium channel blockers	– volume hypertension, mainly in combination with diuretics – renoparenchymatous hypertension – primary low-renin HT	– signs of cardiac ischemia (short-term preparations)	– flush – peripheral edema, mainly around ankles – headaches – excessive hypotension – tachycardia
Diuretics	– salt sensitive hypertension – volume hypertension – hyperaldosteronism (aldosterone antagonists)	– volume depletion – hypokalemia	– hypokalemia (thiazid, loop diuretics) – hyperkalemia (aldosteron antagonists) – hyperglycemia – hyperuricemia

Table 7. Overview of representatives of individual groups of anti- hypertensive agents

Group of medicine	Subgroup and generic name of the product	Recommended dose (mg/kg/day *if not given else*)	Number of daily doses
ACE-inhibitors	Enalapril*	0.1–0.3	2x
	Ramipril*	*1.5–6 (mg/m²/day)*	1x
	Lisinopril	*10–80 (mg/day)*	1x
	Trandolapril	*1–4 (mg/day)*	1x
Angiotensin receptor blockers	Losartan*	0.7–1.4	1x
Beta-blockers	A) non- selective, without ISA:		
	Metipranol	0.5–1	2–3x
	Propranolol*	0.5–6	2–3x
	B) non –selective with ISA:		
	Pindolol	*2.5–10 (mg/day)*	2x
	C) selective without ISA:		
	Atenolol	1–2	1x
	Metoprolol*	0.5–1	2x
	Betaxolol	*5–20 (mg/day)*	1x
	D) selective with ISA:		
	Acebutolol	*200–800 (mg/day)*	1x
	Celiprolol	*100–400 (mg/day)*	1x
Calcium channel blockers	Nifedipin SR, GITS	0.5–3	1–2x
	Amlodipin*	0.5–1	1x
	Nitrendipin*	1–2	1x
	Felodipin*	0.5–1	1x
	Isradipin*	0.5–1	1x
Diuretics	A) thiazid: Hydrochlorothiazid*	0.5–3	2x
	B) loop:		
	Furosemid	1–6	2–4x
	C) aldosterone antagonists:		
	Spironolakton	1–3	2–4x

There is experience with preparations marked with ***,** based on published clinical studies in children.

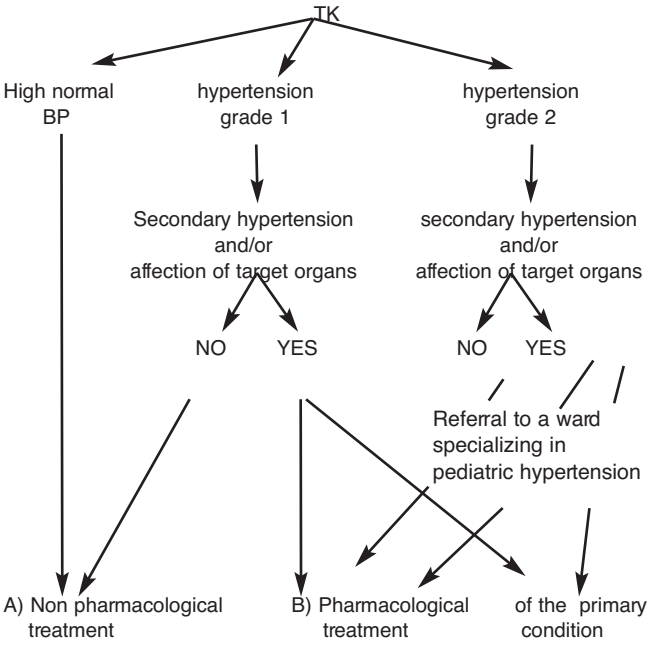

Figure 2. Algorithm of the treatment procedure in a child with hypertension

An overview of basic groups of anti-hypersensitive drugs and their main indications in hypertensive children is presented in Table 6. An overview of the individual anti-hypertensive groups representatives is presented in Table 7.

CONCLUSION

Arterial hypertension occurs in 1 % of children and the most common causes of pediatric hypertension include various forms of secondary hypertension, mostly kidney disorders. Primary/essential hypertension is the most common form in adolescents. In general, the younger the child and the more serious his hypertension, the more likely the secondary hypertension is. Any child with hypertension must undergo thorough examination aimed at detecting possible secondary form of hypertension and its causal therapy.

Abbreviations

ABPM – ambulatory blood pressure monitoring
ACE-inhibitors – angiotensin-converting enzyme inhibitors
CT – computer tomography
HT – hypertension
BP – blood pressure

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