When and how to treat hypertension in the young

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Reference guidelines

National High Blood Pressure Education Program Working Group on
High Blood Pressure in Children and Adolescents

The Fourth Report on the Diagnosis, Evaluation, and Treatment of High Blood Pressure in Children and Adolescents

Pediatrics 2004;114;555

Management of high blood pressure in children and adolescents: recommendations of the European Society of Hypertension

Journal of Hypertension 2009, **27**:1719–1742

Expert Panel on Integrated Guidelines for Cardiovascular Health and Risk Reduction in Children and Adolescents: Summary Report

Pediatrics 2011;128;S213

Diagnosis

혈압 측정 대상자

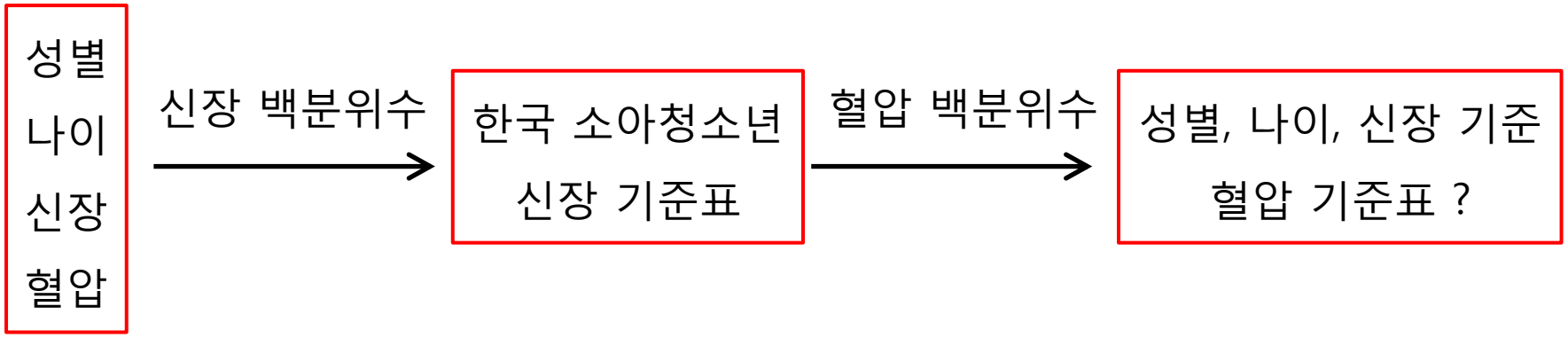
- Children above 3 years of age who are seen in a medical setting should have their BP measured.
- In younger children, BP should be measured under special circumstances

History of prematurity, very low birth weight, or other neonatal complication requiring intensive care
Congenital heart disease (repaired or nonrepaired)
Recurrent urinary tract infections, hematuria, or proteinuria
Known renal disease or urologic malformations
Family history of congenital renal disease
Solid-organ transplant
Malignancy or bone marrow transplant
Treatment with drugs known to raise BP
Other systemic illnesses associated with hypertension (neurofibromatosis, tuberous sclerosis, etc)
Evidence of elevated intracranial pressure

혈압 측정 방법

- The recommended method is auscultatory
- Use K1 for systolic BP and K5 for diastolic BP
- If the oscillometric method is used, the monitor needs to be validated
- If hypertension is detected by the oscillometric method, it needs to be confirmed using the auscultatory method
- Use the appropriate cuff size according to arm width (40% of the arm circumference) and length (4×8 cm, 6×12 cm, 9×18 cm, 10×24 cm, to cover 80–100% of the individual's arm circumference).

소아청소년 고혈압 분류와 기준



Class	SBP and/or DBP percentile
Normal	<90th
High-normal (prehypertension)	≥90th to <95th ≥120/80 even if below 90th percentile in adolescents
Stage 1 hypertension	95th percentile to the 99th percentile plus 5 mmHg
Stage 2 hypertension	>99th percentile plus 5 mmHg

한국 소아청소년 신장 기준표 (2007)

	남아								여아						
	3	10	25	50	75	90	97	(단위:%)	3	10	25	50	75	90	97
12개월	8,50	9,00	9,61	10,30	11,01	11,90	12,75	체중(kg)	8,00	8,60	9,20	9,82	10,78	11,56	12,50
	72,1	74,2	75,8	77,7	79,6	81,6	84,0	신장(cm)	71,3	73,0	74,6	76,6	78,9	81,5	84,3
2년	10,00	11,00	11,80	12,90	14,00	15,00	16,50	체중(kg)	10,00	10,60	11,45	12,50	13,50	14,50	15,30
	78,6	82,5	85,2	88,0	90,4	92,9	96,2	신장(cm)	77,9	82,0	84,7	87,0	89,8	91,8	94,2
3년	11,92	13,00	14,00	15,00	16,10	17,45	19,00	체중(kg)	11,00	12,02	13,00	14,00	15,05	16,50	17,95
	87,9	90,4	92,8	95,7	98,6	101,2	104,0	신장(cm)	85,8	88,7	91,2	94,1	97,0	99,7	102,9
4년	13,41	14,50	15,55	16,80	18,14	19,70	21,50	체중(kg)	13,00	14,00	15,00	16,20	17,61	19,10	21,10
	94,7	98,0	100,9	103,7	106,4	108,9	111,7	신장(cm)	93,5	96,3	99,1	102,2	105,2	107,7	110,3
5년	15,24	16,19	17,35	18,72	20,40	22,23	24,06	체중(kg)	15,06	15,88	16,80	18,14	19,70	21,34	23,28
	100,0	103,7	106,6	109,6	112,8	115,9	118,1	신장(cm)	100,0	102,7	105,5	108,7	111,7	114,8	117,2
6년	17,00	18,00	19,30	20,97	22,90	25,40	29,06	체중(kg)	16,25	17,40	18,64	20,37	22,25	24,36	27,00
	107,0	109,9	112,6	115,6	118,9	121,9	125,1	신장(cm)	105,9	108,7	111,5	114,6	117,9	120,9	123,5
7년	18,96	20,20	21,80	23,80	26,70	30,62	35,40	체중(kg)	18,18	19,40	20,80	22,72	25,70	28,82	23,60
	111,5	115,0	118,8	122,4	126,4	129,7	132,9	신장(cm)	110,2	113,8	117,3	121,0	124,8	128,4	132,0
8년	20,30	21,80	23,77	26,45	30,40	35,20	40,90	체중(kg)	19,30	20,70	22,59	25,40	28,67	32,55	38,16
	115,7	119,4	123,5	127,6	131,6	135,3	138,7	신장(cm)	114,2	118,2	121,7	125,9	130,3	133,9	139,5
9년	22,24	24,04	26,15	29,76	34,30	40,10	46,60	체중(kg)	21,70	23,30	25,46	28,65	33,32	38,50	44,50
	121,5	125,2	128,7	132,7	137,2	140,6	144,0	신장(cm)	120,4	124,0	128,0	132,3	136,4	140,3	144,5

한국 소아청소년 신장 기준표 (2007)

	남아								여아						
	3	10	25	50	75	90	97	(단위:%)	3	10	25	50	75	90	97
10년	24,14	26,30	28,90	32,90	38,70	45,23	52,11	체중(kg)	23,45	25,40	28,30	32,59	37,60	43,46	49,45
	126,0	129,7	133,2	137,7	142,0	146,2	150,2	신장(cm)	125,4	128,7	132,8	137,7	142,3	147,0	151,3
11년	26,08	28,90	32,20	37,00	43,76	50,54	58,20	체중(kg)	25,50	28,00	31,34	36,70	43,10	49,50	55,60
	130,1	134,5	138,8	143,2	148,2	152,8	157,2	신장(cm)	130,0	134,2	138,7	144,1	149,9	154,1	157,9
12년	28,50	31,66	35,80	41,59	48,32	56,30	63,81	체중(kg)	29,04	32,50	37,00	42,36	48,44	54,70	62,10
	135,1	139,5	143,9	148,9	154,5	160,2	165,1	신장(cm)	135,3	141,2	146,6	151,7	156,0	159,5	162,8
13년	31,40	35,00	39,89	46,22	53,40	60,50	68,60	체중(kg)	32,80	36,75	41,00	46,50	52,08	58,25	64,55
	139,7	144,3	149,1	155,3	161,6	166,2	170,0	신장(cm)	143,0	147,3	151,4	155,3	159,2	162,4	165,6
14년	36,50	41,80	46,70	52,86	59,90	68,00	76,85	체중(kg)	37,64	41,06	45,00	50,00	55,10	61,35	67,90
	146,7	153,0	158,6	163,6	168,0	171,5	173,6	신장(cm)	147,0	150,8	154,3	157,8	161,4	164,9	168,0
15년	41,80	46,70	51,30	57,40	64,30	72,40	82,10	체중(kg)	40,50	43,20	47,10	51,52	56,75	62,90	69,50
	153,5	159,5	164,0	168,5	172,4	175,5	178,0	신장(cm)	149,3	152,4	155,3	158,9	162,5	165,9	168,6
16년	46,60	50,70	54,70	59,75	66,20	74,00	84,10	체중(kg)	42,30	45,40	49,20	53,40	58,40	64,50	72,16
	159,2	163,6	167,5	171,2	175,1	178,7	181,1	신장(cm)	150,4	153,3	156,6	160,0	163,7	166,6	169,6
17년	48,60	52,20	56,46	61,70	68,40	76,00	86,30	체중(kg)	43,60	46,30	49,50	54,00	58,30	64,00	70,35
	161,1	165,2	168,5	172,3	176,1	179,8	182,9	신장(cm)	151,0	153,8	156,7	160,1	163,9	167,2	170,5

남아 혈압 기준표 (NHANES 1999-2000)

		Systolic (mmHg) percentile of height							Diastolic (mmHg) percentile of height						
Age (years)	BP percentile	5th	10th	25th	50th	75th	90th	95th	5th	10th	25th	50th	75th	90th	95th
1	90th	94	95	97	99	100	102	103	49	50	51	52	53	53	54
	95th	98	99	101	103	104	106	106	54	54	55	56	57	58	58
	99th	105	106	108	110	112	113	114	61	62	63	64	65	66	66
2	90th	97	99	100	102	104	105	106	54	55	56	57	58	58	59
	95th	101	102	104	106	108	109	110	59	59	60	61	62	63	63
	99th	109	110	111	113	115	117	117	66	67	68	69	70	71	71
3	90th	100	101	103	105	107	108	109	59	59	60	61	62	63	63
	95th	104	105	107	109	110	112	113	63	63	64	65	66	67	67
	99th	111	112	114	116	118	119	120	71	71	72	73	74	75	75
4	90th	102	103	105	107	109	110	111	62	63	64	65	66	66	67
	95th	106	107	109	111	112	114	115	66	67	68	69	70	71	71
	99th	113	114	116	118	120	121	122	74	75	76	77	78	78	79
5	90th	104	105	106	108	110	111	112	65	66	67	68	69	69	70
	95th	108	109	110	112	114	115	116	69	70	71	72	73	74	74
	99th	115	116	118	120	121	123	123	77	78	79	80	81	81	82
6	90th	105	106	108	110	111	113	113	68	68	69	70	71	72	72
	95th	109	110	112	114	115	117	117	72	72	73	74	75	76	76
	99th	116	117	119	121	123	124	125	80	80	81	82	83	84	84
7	90th	106	107	109	111	113	114	115	70	70	71	72	73	74	74
	95th	110	111	113	115	117	118	119	74	74	75	76	77	78	78
	99th	117	118	120	122	124	125	126	82	82	83	84	85	86	86
8	90th	107	109	110	112	114	115	116	71	72	72	73	74	75	76
	95th	111	112	114	116	118	119	120	75	76	77	78	79	79	80
	99th	119	120	122	123	125	127	127	83	84	85	86	87	87	88
9	90th	109	110	112	114	115	117	118	72	73	74	75	76	76	77
	95th	113	114	116	118	119	121	121	76	77	78	79	80	81	81
	99th	120	121	123	125	127	128	129	84	85	86	87	88	88	89

남아 혈압 기준표 (NHANES 1999-2000)

		Systolic (mmHg) percentile of height							Diastolic (mmHg) percentile of height						
Age (years)	BP percentile	5th	10th	25th	50th	75th	90th	95th	5th	10th	25th	50th	75th	90th	95th
10	90th	111	112	114	115	117	119	119	73	73	74	75	76	77	78
	95th	115	116	117	119	121	122	123	77	78	79	80	81	81	82
	99th	122	123	125	127	128	130	130	85	86	86	88	88	89	90
11	90th	113	114	115	117	119	120	121	74	74	75	76	77	78	78
	95th	117	118	119	121	123	124	125	78	78	79	80	81	82	82
	99th	124	125	127	129	130	132	132	86	86	87	88	89	90	90
12	90th	115	116	118	120	121	123	123	74	75	75	76	77	78	79
	95th	119	120	122	123	125	127	127	78	79	80	81	82	82	83
	99th	126	127	129	131	133	134	135	86	87	88	89	90	90	91
13	90th	117	118	120	122	124	125	126	75	75	76	77	78	79	79
	95th	121	122	124	126	128	129	130	79	79	80	81	82	83	83
	99th	128	130	131	133	135	136	137	87	87	88	89	90	91	91
14	90th	120	121	123	125	126	128	128	75	76	77	78	79	79	80
	95th	124	125	127	128	130	132	132	80	80	81	82	83	84	84
	99th	131	132	134	136	138	139	140	87	88	89	90	91	92	92
15	90th	122	124	125	127	129	130	131	76	77	78	79	80	80	81
	95th	126	127	129	131	133	134	135	81	81	82	83	84	85	85
	99th	134	135	136	138	140	142	142	88	89	90	91	92	93	93
16	90th	125	126	128	130	131	133	134	78	78	79	80	81	82	82
	95th	129	130	132	134	135	137	137	82	83	83	84	85	86	87
	99th	136	137	139	141	143	144	145	90	90	91	92	93	94	94
17	90th	127	128	130	132	134	135	136	80	80	81	82	83	84	84
	95th	131	132	134	136	138	139	140	84	85	86	87	87	88	89
	99th	139	140	141	143	145	146	147	92	93	93	94	95	96	97

여아 혈압 기준표 (NHANES 1999-2000)

		Systolic (mmHg) percentile of height							Diastolic (mmHg) percentile of height						
Age (years)	BP percentile	5th	10th	25th	50th	75th	90th	95th	5th	10th	25th	50th	75th	90th	95th
1	90th	97	97	98	100	101	102	103	52	53	53	54	55	55	56
	95th	100	101	102	104	105	106	107	56	57	57	58	59	59	60
	99th	108	108	109	111	112	113	114	64	64	65	65	66	67	67
2	90th	98	99	100	101	103	104	105	57	58	58	59	60	61	61
	95th	102	103	104	105	107	108	109	61	62	62	63	64	65	65
	99th	109	110	111	112	114	115	116	69	69	70	70	71	72	72
3	90th	100	100	102	103	104	106	106	61	62	62	63	64	64	65
	95th	104	104	105	107	108	109	110	65	66	66	67	68	68	69
	99th	111	111	113	114	115	116	117	73	73	74	74	75	76	76
4	90th	101	102	103	104	106	107	108	64	64	65	66	67	67	68
	95th	105	106	107	108	110	111	112	68	68	69	70	71	71	72
	99th	112	113	114	115	117	118	119	76	76	76	77	78	79	79
5	90th	103	103	105	106	107	109	109	66	67	67	68	69	69	70
	95th	107	107	108	110	111	112	113	70	71	71	72	73	73	74
	99th	114	114	116	117	118	120	120	78	78	79	79	80	81	81
6	90th	104	105	106	108	109	110	111	68	68	69	70	70	71	72
	95th	108	109	110	111	113	114	115	72	72	73	74	74	75	76
	99th	115	116	117	119	120	121	122	80	80	80	81	82	83	83
7	90th	106	107	108	109	111	112	113	69	70	70	71	72	72	73
	95th	110	111	112	113	115	116	116	73	74	74	75	76	76	77
	99th	117	118	119	120	122	123	124	81	81	82	82	83	84	84
8	90th	108	109	110	111	113	114	114	71	71	71	72	73	74	74
	95th	112	112	114	115	116	118	118	75	75	75	76	77	78	78
	99th	119	120	121	122	123	125	125	82	82	83	83	84	85	86
9	90th	110	110	112	113	114	116	116	72	72	72	73	74	75	75
	95th	114	114	115	117	118	119	120	76	76	76	77	78	79	79
	99th	121	121	123	124	125	127	127	83	83	84	84	85	86	87

여아 혈압 기준표 (NHANES 1999-2000)

		Systolic (mmHg) percentile of height							Diastolic (mmHg) percentile of height						
Age (years)	BP percentile	5th	10th	25th	50th	75th	90th	95th	5th	10th	25th	50th	75th	90th	95th
10	90th	112	112	114	115	116	118	118	73	73	73	74	75	76	76
	95th	116	116	117	119	120	121	122	77	77	77	78	79	80	80
	99th	123	123	125	126	127	129	129	84	84	85	86	86	87	88
11	90th	114	114	116	117	118	119	120	74	74	74	75	76	77	77
	95th	118	118	119	121	122	123	124	78	78	78	79	80	81	81
	99th	125	125	126	128	129	130	131	85	85	86	87	87	88	89
12	90th	116	116	117	119	120	121	122	75	75	75	76	77	78	78
	95th	119	120	121	123	124	125	126	79	79	79	80	81	82	82
	99th	127	127	128	130	131	132	133	86	86	87	88	88	89	90
13	90th	117	118	119	121	122	123	124	76	76	76	77	78	79	79
	95th	121	122	123	124	126	127	128	80	80	80	81	82	83	83
	99th	128	129	130	132	133	134	135	87	87	88	89	89	90	91
14	90th	119	120	121	122	124	125	125	77	77	77	78	79	80	80
	95th	123	123	125	126	127	129	129	81	81	81	82	83	84	84
	99th	130	131	132	133	135	136	136	88	88	89	90	90	91	92
15	90th	120	121	122	123	125	126	127	78	78	78	79	80	81	81
	95th	124	125	126	127	129	130	131	82	82	82	83	84	85	85
	99th	131	132	133	134	136	137	138	89	89	90	91	91	92	93
16	90th	121	122	123	124	126	127	128	78	78	79	80	81	81	82
	95th	125	126	127	128	130	131	132	82	82	83	84	85	85	86
	99th	132	133	134	135	137	138	139	90	90	90	91	92	93	93
17	90th	122	122	123	125	126	127	128	78	79	79	80	81	81	82
	95th	125	126	127	129	130	131	132	82	83	83	84	85	85	86
	99th	133	133	134	136	137	138	139	90	90	91	91	92	93	93

Indication of ABPM

1) To confirm the diagnosis of hypertension in a patient with hypertension according to casual BP measurements
   - Determine whether sustained hypertension or WCH exists

2) To evaluate for the presence of MH when there is a clinical suspicion of hypertension but normal or prehypertensive casual measurements

3) To assess BP patterns in high-risk patients
   - Assess for abnormal circadian variation in BP, such as blunted dipping or isolated sleep hypertension in patients with diabetes mellitus, CKD, solid organ transplants, and severe obesity with or without sleep-disordered breathing.
   - Assess the severity and persistence of BP elevation in patients at high risk for hypertensive target-organ damage.

4) To evaluate effectiveness of drug therapy for hypertension
   - Confirm BP control in treated patients, especially those with secondary forms of hypertension.
   - Evaluate for apparent drug-resistant hypertension.
   - Determine whether symptoms can be attributed to drug-related hypotension.

Values for ambulatory BP

	Boys						Girls					
	Day			Night			Day			Night		
Height (cm)	75th	90th	95th	75th	90th	95th	75th	90th	95th	75th	90th	95th
120	116/77	122/80	125/82	99/58	103/61	106/63	114/77	118/80	120/82	99/60	103/63	106/65
125	117/76	122/80	125/82	100/58	105/61	108/63	115/77	119/80	121/82	100/60	104/63	107/66
130	117/76	122/80	126/82	101/59	106/62	110/64	116/76	120/80	122/82	101/59	106/63	108/66
135	117/76	123/80	126/82	102/59	108/63	111/65	116/76	120/80	123/82	102/59	107/63	109/66
140	118/76	123/80	126/82	104/60	109/63	113/65	117/76	121/80	124/82	103/59	108/63	110/66
145	119/76	124/79	127/81	105/60	111/64	114/66	118/76	123/80	125/82	103/59	109/63	112/66
150	120/76	125/79	128/81	106/60	112/64	116/66	119/76	124/80	127/82	104/59	110/63	113/66
155	122/76	127/79	130/81	107/60	113/64	117/66	121/76	125/80	128/82	106/59	111/63	114/66
160	124/76	129/79	133/81	108/60	114/64	118/66	122/76	126/80	129/82	106/59	111/63	114/66
165	126/76	132/80	135/82	110/60	116/64	119/66	123/77	127/80	130/82	107/59	112/63	114/66
170	128/77	134/80	138/82	112/61	117/64	121/66	124/77	128/80	131/82	108/61	112/67	115/71
175	130/77	136/81	140/83	113/61	119/64	122/66	125/78	129/81	131/82	109/59	113/63	115/66
180	132/77	138/81	142/83	115/61	120/64	124/66	N/A	N/A	N/A	N/A	N/A	N/A
185	134/78	140/81	144/84	116/61	122/64	125/66	N/A	N/A	N/A	N/A	N/A	N/A

	Boys						Girls					
	Day			Night			Day			Night		
Age (years)	75th	90th	95th	75th	90th	95th	75th	90th	95th	75th	90th	95th
5	116/76	120/79	123/81	99/59	103/62	106/65	114/77	118/80	121/82	100/61	105/66	108/69
6	116/76	121/79	124/81	100/59	105/63	108/66	115/77	120/80	122/82	101/61	106/65	110/68
7	117/76	122/80	125/82	101/60	106/64	110/67	116/77	121/80	123/82	102/60	107/65	111/67
8	117/76	122/80	125/82	102/60	108/64	111/67	117/76	122/80	124/82	103/60	108/64	112/67
9	118/76	123/80	126/82	103/60	109/64	112/67	118/76	122/80	125/82	103/59	109/64	112/67
10	119/76	124/80	127/82	104/60	110/64	113/67	119/76	123/79	126/81	104/59	110/64	113/67
11	121/76	126/80	129/82	105/60	111/64	115/67	120/76	124/79	127/81	105/59	110/63	114/66
12	123/76	128/80	132/82	107/60	113/64	116/67	121/76	125/80	128/82	105/59	110/63	114/66
13	126/76	131/80	135/82	109/60	115/64	119/67	122/77	126/80	129/82	106/59	111/63	114/66
14	129/77	134/80	138/82	112/61	118/64	121/67	123/77	127/80	130/82	106/59	111/63	114/65
15	132/77	137/81	141/83	114/61	120/64	123/66	124/77	128/80	130/82	107/59	111/63	114/65
16	135/78	140/81	144/84	117/61	123/64	126/66	124/77	129/80	131/82	107/59	111/63	114/65

Classification of ambulatory BP

Classification	Office BP*	Mean Ambulatory SBP or DBP†‡	SBP or DBP Load, %‡§
Normal BP	<90th %tile	<95th %tile	<25
White coat hypertension	≥95th %tile	<95th %tile	<25
Prehypertension	≥90th %tile or >120/80 mm Hg	<95th %tile	≥25
Masked hypertension	<95th %tile	>95th %tile	≥25
Ambulatory hypertension‖	>95th %tile	>95th %tile	25–50
Severe ambulatory hypertension (at risk for end-organ damage)	>95th %tile	>95th %tile	>50

%tile indicates percentile; BP, blood pressure; DBP, diastolic blood pressure; and SBP, systolic blood pressure.

*Based on National High Blood Pressure Education Program Task Force normative data.[101a]

†Based on normative pediatric ABPM values in Appendix Tables A1 through A4.

‡For either the wake or sleep period of the study, or both.

§For patients with elevated load but normal mean ambulatory BP and office BP that is either normal (<90th percentile) or hypertensive (≥95th percentile), no specific ambulatory BP classification can be assigned based on current evidence and expert consensus. These "unclassified" patients should be evaluated on a case-by-case basis, taking into account the presence of secondary hypertensiona or multiple cardiovascular risk factors.

‖Some clinicians may prefer the term *sustained hypertension* rather than *ambulatory hypertension*.

History taking

- FAMILY HISTORY
  - Hypertension
  - Cardiovascular and cerebrovascular disease
  - Diabetes mellitus
  - Dyslipidemia
  - Obesity
  - Hereditary renal disease (Policystic kidney disease)
  - Hereditary endocrine disease (pheochromocytoma, glucocorticoid-remediable aldosteronism, multiple endocrine neoplasia type 2, von Hippel–Lindau)
  - Syndromes associated with hypertension (neurofibromatosis)

History taking

❖ **Perinatal history**

Birth weight, gestational age, oligohydramnios,

anoxia, umbilical artery catheterization

❖ **Previous history**

Hypertension

Urinary tract infection, renal or urological disease

Cardiac, endocrine (including diabetes) or neurological

disease

Growth retardation

❖ **Symptoms suggestive of secondary hypertension**

Dysuria, thirst/polyuria, nocturia, hematuria

Edema, weight loss, failure to thrive

Palpitations, sweating, fever, pallor, flushing

Cold extremities, intermittent claudication

Virilization, primary amenorrhea and male

pseudohermaphroditism

❖ **Symptoms suggestive of target organ damage**

Headache, epistaxis, vertigo, visual impairment

Facial palsy, fits, strokes, dyspnea

❖ **Sleep history**

Snoring, apnea, daytime somnolence

❖ **Risk factor history**

Physical exercise, dietary habits

Smoking, alcohol

❖ **Drug intake**

Anti-hypertensives

Steroids, cyclosporine, tacrolimus or other

Tricyclic anti-depressants, atypical antipsycotics,

decongestants

Oral contraceptives, illegal drugs

Pregnancy

Physical examination

- **Height, weight, body mass index**

- **External features of syndromes/conditions associated with hypertension**

Neurofibromatosis, Klippel–Trenaunay–Weber, Feuerstein–Mims, von Hippel–Lindau, multiple endocrine neoplasia, pseudoxanthoma elasticum, Turner, William, Marfan, Cushing, hyperthyroidism, lupus, vasculitis, congenital adrenal hyperplasia

- **Cardiovascular examination**

Pulse and BP measurement in both arms and legs

Bruits/murmurs – heart, abdomen, flanks, back, neck, head

Signs of left ventricular hypertrophy or cardiac failure

- **Abdomen**

Masses – Wilms, neuroblastoma, pheochromocytoma, autosomal dominant and recessive polycystic kidney disease, multicystic kidney displasia, obstructive uropathy

Hepatosplenomegaly – autosomal recessive polycystic kidney disease

- **Neurological examination**

Fundoscopy for hypertensive changes and retinal amartoma (von Hippel–Lindau)

Evidence of VIII nerve palsy

Other neurological defects including stroke

Laboratory investigation

❖ **Routine tests that have to be performed in all hypertensive children**

Full blood count

Plasma sodium, potassium and calcium, urea, creatinine

Fasting plasma glucose

Serum lipids (cholesterol, LDL cholesterol, HDL cholesterol)

Fasting serum triglycerides

Urinalysis plus quantitative measurement of microalbuminuria and proteinuria

Renal ultrasound

Chest Xray, ECG and 2-D echocardiography

❖ **Recommended additional screening tests**

Plasma renin activity, plasma aldosterone concentration

Urine and plasma catecholamines or metanephrines

Tc99 dimercaptosuccinic acid scan

Urinary free cortisol

❖ **More sophisticated tests that should await results of above screening**

Color Doppler ultrasonography

Captopril primed isotope studies

Renal vein renin measurements

Renal angiography

I123 metaiodobenzylguanidine scanning

Computed tomography/ Magnetic resonance imaging

Urine steroid analyses and more complex endocrine investigations

Molecular genetic studies (Apparent mineralocorticoid excess, Liddle's syndrome, etc)

Diagnosis of secondary hypertension

❖ **Chronic kidney disease**

Protein, erythrocytes and erythrocyte casts in urine

Serum creatinine concentration and potassium

Abdominal ultrasound

[99Tcm]dimercaptosuccinic acid static scanning

❖ **Renovascular hypertension**

Plasma renin activity

Abdominal ultrasound

Doppler ultrasound

Renal scintigraphy

MRI angiography

Angiography

❖ **Pheochromocytoma and paraganglioma**

24-h urine and plasma chatecolamines or metanephrines

Magnetic resonance image

I123 metaiodobenzylguanidine

Primary aldosteronism

Plasma renin activity

Plasma aldosterone

❖ **Cushing's syndrome**

Plasma cortisol, ACTH

24-h urinary free cortisol

❖ **Coarctation of aorta**

Rx chest

Echocardiography

Magnetic resonance image angiography

Aortography

❖ **Mendelian**

DNA testing

❖ **Drug-induced**

Liquorice, oral contraceptives, glucocorticoids, non-steroidal anti-inflammatory drugs, sympathomimetics, erythropoietin,

cyclosporine, tacrolimus, cocaine, metabolic steroids

❖ **Hyperthyroidism**

TSH, FT3, FT4

❖ **Congenital adrenal hyperplasia**

Plasma deoxycorticosterone and corticosterone,

18-hydroxycorticosterone, 18-hydroxy deoxycorticosterone,

11 deoxycortisol

Treatment

- Life-style modification
  - Weight control
  - Diet
  - activity
- Drug therapy

Life-style recommendation

❖ **WEIGHT MANAGEMENT**

ESH →

BMI<85th percentile: Maintain BMI to prevent overweight

BMI 85–95th percentile: Weight maintenance (younger children) or gradual weight loss in adolescents to reduce BMI to <85th percentile

BMI>95th percentile: Gradual weight loss (1–2 kg/month) to achieve value <85th percentile

NHLBI →

The 2010 DGA8 recommends slowing weight gain while allowing normal growth and development.

For those with a BMI at the 95th percentile without comorbidities, both the AMA/CDC/MCHB expert committee and the AAP16 recommend weight maintenance resulting in decreasing BMI as age increases.

With a BMI at the 95th percentile with comorbidities, the AMA/CDC/MCHB expert committee and the AAP16 recommend gradual weight loss not to exceed 1 lb/month in children aged 2 to 11 years or 2 lb/week in adolescents.

Life-style recommendation

❖ **GENERAL RECOMMENDATIONS**

- Moderate to vigorous physical aerobic activity 40 min, 3–5 days/week and avoid more than 2 h daily of sedentary activities
- Avoid intake of excess sugar, excess soft drinks, saturated fat and salt and recommend fruits, vegetables and grain products
- Implement the behavioral changes (physical activity and diet) tailored to individual and family characteristics
- Involve the parents/family as partners in the behavioral change process
- Provide educational support and materials
- Establish realistic goals
- Develop a health-promoting reward system
- Competitive sports participation should be limited only in the presence of uncontrolled stage 2 hypertension

Recommendations for Diet and Nutrition: CHILD-1

Birth to 6 mo	Infants should be exclusively breastfed (no supplemental formula or other foods) until the age of 6 mo[a]	Grade B Strongly recommend
6 to 12 mo	Continue breastfeeding until at least 12 mo of age while gradually adding solids; transition to iron-fortified formula until 12 mo if reducing breastfeeding[a]	Grade B Strongly recommend
	Fat intake in infants <12 mo of age should not be restricted without medical indication	Grade D Recommend
	Limit other drinks to 100% fruit juice (≤4 oz/d); no sweetened beverages; encourage water	Grade D recommend
12 to 24 mo	Transition to reduced-fat[b] (2% to fat-free) unflavored cow's milk[c] (see supportive actions)	Grade B Recommend
	Limit/avoid sugar-sweetened beverage intake; encourage water	Grade B Strongly recommend
	Transition to table food with:	
	Total fat 30% of daily kcal/EER[d]	Grade B Recommend
	Saturated fat 8%–10% of daily kcal/EER	Grade B Recommend
	Avoid trans fat as much as possible	Grade D Strongly recommend
	Monounsaturated and polyunsaturated fat up to 20% of daily kcal/EER	Grade D recommend
	Cholesterol < 300 mg/d	Grade B Strongly recommend
	Supportive actions The fat content of cow's milk to introduce at 12–24 mo of age should be decided together by parents and health care providers on the basis of the child's growth, appetite, intake of other nutrient-dense foods, intake of other sources of fat, and potential risk for obesity and CVD 100% fruit juice (from a cup), no more than 4 oz/d Limit sodium intake Consider DASH-type diet rich in fruits, vegetables, whole grains, and low-fat/fat-free milk and milk products and lower in sugar (Table 5-3)	

Recommendations for Diet and Nutrition: CHILD-1

2 to 10 y	Primary beverage: fat-free unflavored milk	Grade A Strongly recommend
	Limit/avoid sugar-sweetened beverages; encourage water	Grade B Recommend
	Fat content:	
	Total fat 25%–30% of daily kcal/EER	Grade A Strongly recommend
	Saturated fat 8%–10% of daily kcal/EER	Grade A Strongly recommend
	Avoid trans fats as much as possible	Grade D, recommend
	Monounsaturated and polyunsaturated fat up to 20% of daily kcal/EER	Grade D Recommend
	Cholesterol < 300 mg/d	Grade A Strongly Recommend
	Encourage high dietary fiber intake from foods[e]	Grade B recommend
	Supportive actions:	
	Teach portions based on EER for age/gender/age (Table 5-2)	
	Encourage moderately increased energy intake during periods of rapid growth and/or regular moderate-to-vigorous physical activity	
	Encourage dietary fiber from foods: age + 5 g/d[e]	
	Limit naturally sweetened juice (no added sugar) to 4 oz/d	
	Limit sodium intake	
	Support DASH-style eating plan (Table 5-3)	

Recommendations for Diet and Nutrition: CHILD-1

11 to 21 y	Primary beverage: fat-free unflavored milk	Grade A Strongly recommend
	Limit/avoid sugar-sweetened beverages; encourage water	Grade B Recommend
	100% fruit juice (from a cup), no more than 4 oz/d Limit sodium intake Consider DASH-type diet rich in fruits, vegetables, whole grains, and low-fat/fat-free milk and milk products and lower in sugar (Table 5-3)	
	Fat content:	
	Total fat 25%–30% of daily kcal/EER[d]	Grade A Strongly recommend
	Saturated fat 8%–10% of daily kcal/EER	Grade A Strongly recommend
	Avoid trans fat as much as possible	Grade D Recommend
	Monounsaturated and polyunsaturated fat up to 20% of daily kcal/EER	Grade D Recommend
	Cholesterol < 300 mg/d	Grade A Strongly recommend
	Encourage high dietary fiber intake from foods[e]	Grade B Recommend
	Supportive actions: Teach portions based on EER for age/gender/activity (Table 5-2) Encourage moderately increased energy intake during periods of rapid growth and/or regular moderate-to-vigorous physical activity Advocate dietary fiber: goal of 14 g/1000 kcal[e] Limit naturally sweetened juice (no added sugar) to 4–6 oz/d Limit sodium intake Encourage healthy eating habits: breakfast every day, eating meals as a family, limiting fast-food meals Support DASH-style eating plan (Table 5-3)	

Estimated Calorie Needs per Day

Gender	Age (Years)	Calorie Requirements (kcals) by Activity Level[b]		
		Sedentary	Moderately Active	Active
Child	2–3	1000–1200	1000–1400[c]	1000–1400[c]
Female[d]	4–8	1200–1400	1400–1600	1400–1800
	9–13	1400–1600	1600–2000	1800–2200
	14–18	1800	2000	2400
	19–30	1800–2000	2000–2200	2400
Male	4–8	1200–1400	1400–1600	1600–2000
	9–13	1600–2000	1800–2200	2000–2600
	14–18	2000–2400	2400–2800	2800–3200
	19–30	2400–2600	2600–2800	3000

DASH Eating Plan: Servings per Day

Food Group	No. of Servings						Serving Size	Examples and Notes	Significance of Each Food Group to the DASH Eating Plan
	1200 cal	1400 cal	1600 cal	1800 cal	2000 cal	2600 cal			
Grains[a]	4–5/d	5–6/d	6/d	6/d	6–8/d	10–11/d	1 slice bread; 1 oz dry cereal[b]; ½ cup cooked rice, pasta, or cereal[b]	Whole-wheat bread and rolls, whole-wheat pasta, English muffin, pita bread, bagel, cereals, grits, oatmeal, brown rice, unsalted pretzels and popcorn	Major sources of energy and fiber
Vegetables	3–4/d	3–4/d	3–4/d	4–5/d	4–5/d	5–6/d	1 cup raw leafy vegetable; ½ cup cut-up raw or cooked vegetable; ½ cup vegetable juice	Broccoli, carrots, collards, green beans, green peas, kale, lima beans, potatoes, spinach, squash, sweet potatoes, tomatoes	Rich sources of potassium, magnesium, and fiber
Fruits	3–4/d	4/d	4/d	4–5/d	4–5/d	5–6/d	1 medium fruit; ¼ cup dried fruit; ½ cup fresh, frozen, or canned fruit; ½ cup fruit juice	Apples, apricots, bananas, dates, grapes, oranges, grapefruit, grapefruit juice, mangoes, melons, peaches, pineapples, raisins, strawberries, tangerines	Important sources of potassium, magnesium, and fiber
Fat-free or low-fat milk and milk products	2–3/d	2–3/d	2–3/d	2–3/d	2–3/d	3/d	1 cup milk or yogurt; 1½ oz cheese	Fat-free milk or buttermilk, fat-free, low-fat, or reduced-fat cheese, fat-free/low-fat regular or frozen yogurt	Major sources of calcium and protein

DASH Eating Plan: Servings per Day

Food Group	No. of Servings						Serving Size	Examples and Notes	Significance of Each Food Group to the DASH Eating Plan
	1200 cal	1400 cal	1600 cal	1800 cal	2000 cal	2600 cal			
Lean meats, poultry, and fish	≤3/d	≤3–4/d	≤3–4/d	≤6/d	≤6/d	≤6/d	1 oz cooked meats, poultry, or fish; 1 egg[c]	Select only lean; trim away visible fats; broil, roast, or poach; remove skin from poultry	Rich sources of protein and magnesium
Nuts, seeds, and legumes	3/wk	3/wk	3–4/wk	4/wk	4–5/wk	1/d	⅓ cup or 1½ oz nuts; 2 tbsp peanut butter; 2 tbsp or ½ oz seeds; ½ cup cooked legumes (dry beans and peas)	Almonds, filberts, mixed nuts, peanuts, walnuts, sunflower seeds, peanut butter, kidney beans, lentils, split peas	Rich sources of energy, magnesium, protein, and fiber
Fats and oils[d]	1/d	1/d	2/d	2–3/d	2–3/d	3/d	1 tsp soft margarine; 1 tsp vegetable oil; 1 tbsp mayonnaise; 2 tbsp salad dressing	Soft margarine, vegetable oil (such as canola, corn, olive, or safflower), low-fat mayonnaise, light salad dressing	The DASH study had 27% of calories as fat, including fat in or added to foods
Sweets and added sugars	≤3/wk	≤3/wk	≤3/wk	≤5/wk	≤5/wk	≤2/d	1 tbsp sugar; 1 tbsp jelly or jam; ½ cup sorbet, gelatin; 1 cup lemonade	Fruit-flavored gelatin, fruit punch, hard candy, jelly, maple syrup, sorbet and ices, sugar	Sweets should be low in fat

Activity Recommendation

Newborn to 12 mo	Parents should create an environment that promotes and models physical activity and limits sedentary time	Grade D Recommend
	Supportive actions:	
	Discourage TV viewing altogether	
1 to 4 y	Allow unlimited active playtime in safe, supportive environments	Grade D Recommend
	Limit sedentary time, especially TV/video	Grade D Recommend
	Supportive actions:	
	Limit total media time to no more than 1-2 hours of quality programming per day	
	For children ≤2 y old, discourage TV viewing altogether	
	No TV in child's bedroom	
	Encourage family activity at least once per week	
	Counsel routine activity for parents as role models for children	
5 to 10 y	Moderate-to-vigorous physical activity every day[a]	Grade A Strongly recommend
	Limit daily leisure screen time (TV/video/computer)	Grade B Strongly recommend
	Supportive actions:	
	Prescribe moderate-to-vigorous activity 1 h/d[a] with vigorous-intensity physical activity 3 d/wk[b]	
	Limit total media time to no more than 1–2 h/d of quality programming	
	No TV in child's bedroom	
	Take activity and screen-time history from child once per year	
	Match physical activity recommendations with energy intake	
	Recommend appropriate safety equipment relative to each sport	
	Support recommendations for daily physical education in schools	

Activity Recommendation

11 to 17 y	Moderate-to-vigorous physical activity every day[a]	Grade A Strongly recommend
	Limit leisure time TV/video/computer use	Grade B Strongly recommend
	Supportive actions:	
	Encourage adolescents to aim for 1 h/d of moderate-to-vigorous daily activity[a] with vigorous intense physical activity[b] 3 d/wk	
	Encourage no TV in bedroom	
	Limit total media time to no more than 1–2 h/d of quality programming	
	Match activity recommendations with energy intake	
	Take activity and screen-time history from adolescent at health supervision visits	
	Encourage involvement in year-round physical activities	
	Support continued family activity once per week and/or family support of adolescent's physical activity program	
	Endorse appropriate safety equipment relative to each sport	
18 to 21 y	Moderate-to-vigorous physical activity every day[a]	Grade A Strongly recommend
	Limit leisure time TV/video/computer	Grade B Strongly recommend
	Supportive actions:	
	Support goal of 1 h/d of moderate-to-vigorous activity with vigorous intense physical activity 3 d/wk	
	Recommend that combined leisure screen time not exceed 2 h/d	
	Activity and screen-time history at health supervision visits	
	Encourage involvement in year-round, lifelong physical activities	

Management of Overweight and Obesity

Birth to 24 mo	No weight-for-height–specific recommendations CHILD-1 diet is recommended for pediatric care providers to use with their child and adolescent patients to reduce cardiovascular risk	
2 to 5 y	Identify children at high risk for obesity because of parental obesity and excessive BMI increase	Grade B Recommend
	Focused CHILD-1 diet and physical activity education BMI percentile stable: reinforce current program, follow-up in 6 mo Increasing BMI percentile: RD counseling for energy-balanced diet, intensify physical activity change; 6-mo follow-up	
	BMI = 85th–95th percentile Excess weight-gain prevention with parents as focus for energy-balanced diet; reinforce physical activity recommendations for 6 mo	Grade D Recommend
	Improvement in BMI percentile: continue current program Increasing BMI percentile: RD counseling for energy-balanced diet; intensify physical activity recommendations; 6-mo follow-up	
	BMI ≥ 95th percentile Specific assessment for comorbidities[a]	Grade B Strongly recommend
	Family-based weight-gain prevention with parents as focus; RD counseling and follow-up for energy-balanced diet; MVPA prescription; limit sedentary screen time; 3-mo follow-up	Grade B Recommend
6 to 11 y	Identify children at increased risk for obesity because of parental obesity, change in physical activity ± excessive gain in BMI for focused CHILD-1 diet/physical activity education	Grade B Recommend
	BMI percentile stable: reinforce current program, 6-mo follow-up Increasing BMI percentile: RD counseling for energy-balanced CHILD-1 diet, intensified physical activity, 3 mo follow-up	
	BMI = 85th–95th percentile Excessive weight-gain prevention with parents as focus for energy-balanced diet; reinforce physical activity recommendations, 6-mo follow-up	Grade D Recommend
	Stable/improving BMI percentile: reinforce current program, 6-mo follow-up Increasing BMI percentile: RD counseling for energy-balanced CHILD-1 diet, intensified physical activity recommendations, 3-mo follow-up	
	BMI ≥ 95th percentile Specific assessment for comorbidities[a]	Grade B Strongly recommend
	BMI ≥ 95th percentile with no comorbidities Office-based weight-loss plan: family-centered program with parents as focus for behavior modification, (−) energy-balanced diet, counseling by RD, prescription for increased MVPA, decreased sedentary time for 6 mo	Grade A Strongly recommend
	Improvement in BMI percentile/comorbidities: continue current plan No improvement in BMI percentile: refer to comprehensive multidisciplinary lifestyle weight-loss program	
	BMI ≥ 95th percentile with comorbidities, BMI > 97th percentile, or progressive rise in BMI despite therapy Refer to comprehensive multidisciplinary weight-loss program for intensive management for 6 mo	Grade A Strongly recommend
	Improvement in BMI percentile: continue current program No improvement in BMI percentile: consider referral to another comprehensive multidisciplinary weight-loss program	

Management of Overweight and Obesity

12 to 21 y	Identify adolescents at increased risk for obesity because of parental obesity, change in physical activity ± excess gain in BMI for focused diet/physical activity education for 6 mo	Grade B Recommend
	BMI/BMI percentile stable: reinforce current program, 6-mo follow-up	
	Increasing BMI/BMI percentile: RD counseling for energy-balanced CHILD-1 diet, intensified physical activity for 3 mo	
	BMI = 85th–95th percentile	
	Excess weight-gain prevention with adolescent as change agent for energy-balanced CHILD-1 diet, reinforced physical activity recommendations for 6 mo	Grade B Recommend
	Improvement in BMI percentile: continue current program	
	Increasing BMI percentile: RD counseling for energy-balanced weight-control diet, intensified physical activity, 3-mo follow-up	
	BMI ≥ 95th percentile	
	Specific assessment for comorbidities[a]	Grade B
	BMI ≥ 95th percentile with no comorbidities	Strongly recommend
	Office-based weight-loss plan: family-centered with adolescent as change agent for behavior-modification counseling, RD counseling for (−) energy-balanced diet, prescription for increased MVPA, decreased sedentary time for 6 mo	Grade B Strongly recommend
	Improvement in BMI/BMI percentile: continue current program	
	No improvement in BMI/BMI percentile: refer to comprehensive multidisciplinary weight-loss program with peers	
	No improvement in BMI/BMI percentile: consider initiation of medication (orlistat) under care of experienced clinician for 6–12 mo	
	BMI ≥ 95th percentile with comorbidities or BMI > 35	
	Refer to comprehensive lifestyle weight-loss program for intensive management for 6–12 mo	Grade A
	Improvement in BMI/BMI percentile: continue current program	Strongly recommend
	No improvement in BMI/BMI percentile: consider initiation of orlistat under care of experienced clinician for 6–12 mo	
	If BMI is far above 35 and comorbidities unresponsive to lifestyle therapy for >1 y, consider bariatric surgery/referral to center with experience/expertise in procedures	

Indication of drug therapy

Symptomatic hypertension
Secondary hypertension
Hypertensive target-organ damage
Diabetes (types 1 and 2)
Persistent hypertension despite nonpharmacologic measures

Antihypertensive medication

Class	Drug	Initial Dose[a]	Maximal Dose	Dosing Interval	Evidence[b]	FDA[c]	Comments[d]
ACE inhibitors	Benazepril	0.2 mg/kg per d up to 10 mg/d	0.6 mg/kg per d up to 40 mg/d	QD	RCT	Yes	1. All ACE inhibitors are contraindicated in pregnancy; women of childbearing age should use reliable contraception
	Captopril	0.3–0.5 mg/kg per dose (>12 mo)	6 mg/kg per d	TID	RCT, CS	No	2. Check serum potassium and creatinine periodically to monitor for hyperkalemia and azotemia
							3. Cough and angioedema are reportedly less common with newer members of this class than with captopril
	Fosinopril[e]	Children >50 kg: 5–10 mg/d	40 mg/d	QD	RCT	Yes	4. Benazepril, enalapril, and lisinopril labels contain information on the preparation of a suspension; captopril may also be compounded into a suspension
	Lisinopril[e]	0.07 mg/kg per d up to 5 mg/d	0.6 mg/kg per d up to 40 mg/d	QD	RCT	Yes	5. FDA approval for ACE inhibitors with pediatric labeling is limited to children ≥6 y of age and to children with creatinine clearance rate of ≥30 mL/min per 1.73 m^2
	Quinapril	5–10 mg/d	80 mg/d	QD	RCT, EO	No	6. Initial dose of fosinopril of 0.1 mg/kg per d may be effective, although black patients might require a higher dose
ARBs	Irbesartan	6–12 y: 75–150 mg/d; ≥13 y: 150–300 mg/d	300 mg/d	QD	CS	Yes	1. All ARBs are contraindicated in pregnancy; women of childbearing age should use reliable contraception
	Losartan[e]	0.7 mg/kg per d up to 50 mg/d	1.4 mg/kg per d up to 100 mg/d	QD–BID	RCT	Yes	2. Check serum potassium and creatinine levels periodically to monitor for hyperkalemia and azotemia
	Valsartan[e]	5–10 mg/d; 0.4 mg/kg per d	40–80 mg/d; 3.4 mg/kg per d	QD	RCT	No	3. Losartan label contains information on the preparation of a suspension
							4. FDA approval for ARBs is limited to children ≥6 y of age and to children with creatinine clearance rate of ≥30 mL/min per 1.73 m^2

Antihypertensive medication

Class	Drug	Initial Dose[a]	Maximal Dose	Dosing Interval	Evidence[b]	FDA[c]	Comments[d]
α- and β-antagonist	Labetalol	1–3 mg/kg per d	10–12 mg/kg per d up to 1200 mg/d	BID	CS, EO	No	1. Asthma and overt heart failure are relative contraindications 2. Heart rate is dose-limiting 3. May impair athletic performance in athletes 4. Should not be used in insulin-dependent diabetic patients
β-antagonists	Atenolol	0.5–1 mg/kg per d	2 mg/kg per d up to 100 mg/d	QD–BID	CS	No	1. Noncardioselective agents (propranolol) are contraindicated in asthma and heart failure
	Bisoprolol/ hydrochlorothiazide	2.5–6.25 mg/d	10/6.25 mg/d	QD	RCT	No	2. Heart rate is dose-limiting
	Metoprolol[e]	Children >6 y: 1 mg/kg per d (12.5–50 mg/d)	2 mg/kg per d up to 200 mg/d	BID	CS	Yes[f]	3. May impair athletic performance in athletes
	Propranolol	1–2 mg/kg per d	4 mg/kg per d up to 640 mg/d	BID–TID	RCT, EO	Yes	4. Should not be used in insulin-dependent diabetic patients 5. A sustained-release, once-daily formulation of propranolol is available
Calcium-channel blockers	Amlodipine[e]	Children 6–17 y: 2.5 mg/d	5 mg/d	QD	RCT	Yes	1. Amlodipine and isradipine can be compounded into stable extemporaneous suspensions
	Felodipine	2.5 mg/d	10 mg/d	QD	RCT, EO	No	2. Felodipine and extended-release nifedipine tablets must be swallowed whole
	Isradipine	0.15–0.2 mg/kg per d	0.8 mg/kg per d up to 20 mg/d	TID–QID	CS, EO	No	3. Isradipine is available in both immediate- and sustained-release formulations; sustained release form is dosed QD or BID
	Extended-release nifedipine	0.25–0.5 mg/kg per d	3 mg/kg per d up to 120 mg/d	QD–BID	CS, EO	No	4. May cause tachycardia 5. Doses up to 10 mg of amlodipine have been evaluated in children 6. Contraindicated for children <1 y of age

Antihypertensive medication

Class	Drug	Initial Dose[a]	Maximal Dose	Dosing Interval	Evidence[b]	FDA[c]	Comments[d]
Central α-agonist	Clonidine	Children ≥12 y: 0.2 mg/d	2.4 mg/d	BID	EO	Yes	1. May cause dry mouth and/or sedation 2. Transdermal preparation is available 3. Sudden cessation of therapy can lead to severe rebound hypertension
Diuretics	Hydrochlorothiazide	1 mg/kg per d	3 mg/kg per d up to 50 mg/d	QD	EO	Yes	1. All patients treated with diuretics should have their electrolytes monitored shortly after initiating therapy and periodically thereafter 2. Useful as add-on therapy in patients being treated with drugs from other drug classes 3. Potassium-sparing diuretics (spironolactone, triamterene, amiloride) may cause severe hyperkalemia, especially if given with an ACE inhibitor or ARB 4. Furosemide is labeled only for treatment of edema but may be useful as add-on therapy in children with resistant hypertension, particularly in children with renal disease 5. Chlorthalidone may precipitate azotemia in patients with renal diseases and should be used with caution in those with severe renal impairment
	Chlorthalidone	0.3 mg/kg per d	2 mg/kg per d up to 50 mg/d	QD	EO	No	
	Furosemide	0.5–2.0 mg/kg per dose	6 mg/kg per d	QD–BID	EO	No	
	Spironolactone	1 mg/kg per d	3.3 mg/kg per d up to 100 mg/d	QD–BID	EO	No	
	Triamterene	1–2 mg/kg per d	3–4 mg/kg per d up to 300 mg/d	BID	EO	No	
	Amiloride	0.4–0.625 mg/kg per d	20 mg/d	QD	EO	No	

Antihypertensive medication

Class	Drug	Initial Dose[a]	Maximal Dose	Dosing Interval	Evidence[b]	FDA[c]	Comments[d]
Peripheral α-antagonists	Doxazosin	1 mg/d	4 mg/d	QD	EO	No	1. May cause first-dose hypotension
	Prazosin	0.05–0.1 mg/kg per day	0.5 mg/kg per d	TID	EO	No	
	Terazosin	1 mg/d	20 mg/d	QD	EO	No	
Vasodilators	Hydralazine	0.75 mg/kg per d	7.5 mg/kg per d up to 200 mg/d	QID	EO	Yes	1. Tachycardia and fluid retention are common adverse effects
	Minoxidil	Children <12 y: 0.2 mg/kg per d; children >12 y: 5 mg/d	Children <12 y: 50 mg/d; children ≥12 y: 100 mg/d	QD–TID	CS, EO	Yes	2. Hydralazine can cause a lupus-like syndrome in slow acetylators 3. Prolonged use of minoxidil can cause hypertrichosis 4. Minoxidil is usually reserved for patients with hypertension that is resistant to multiple drugs

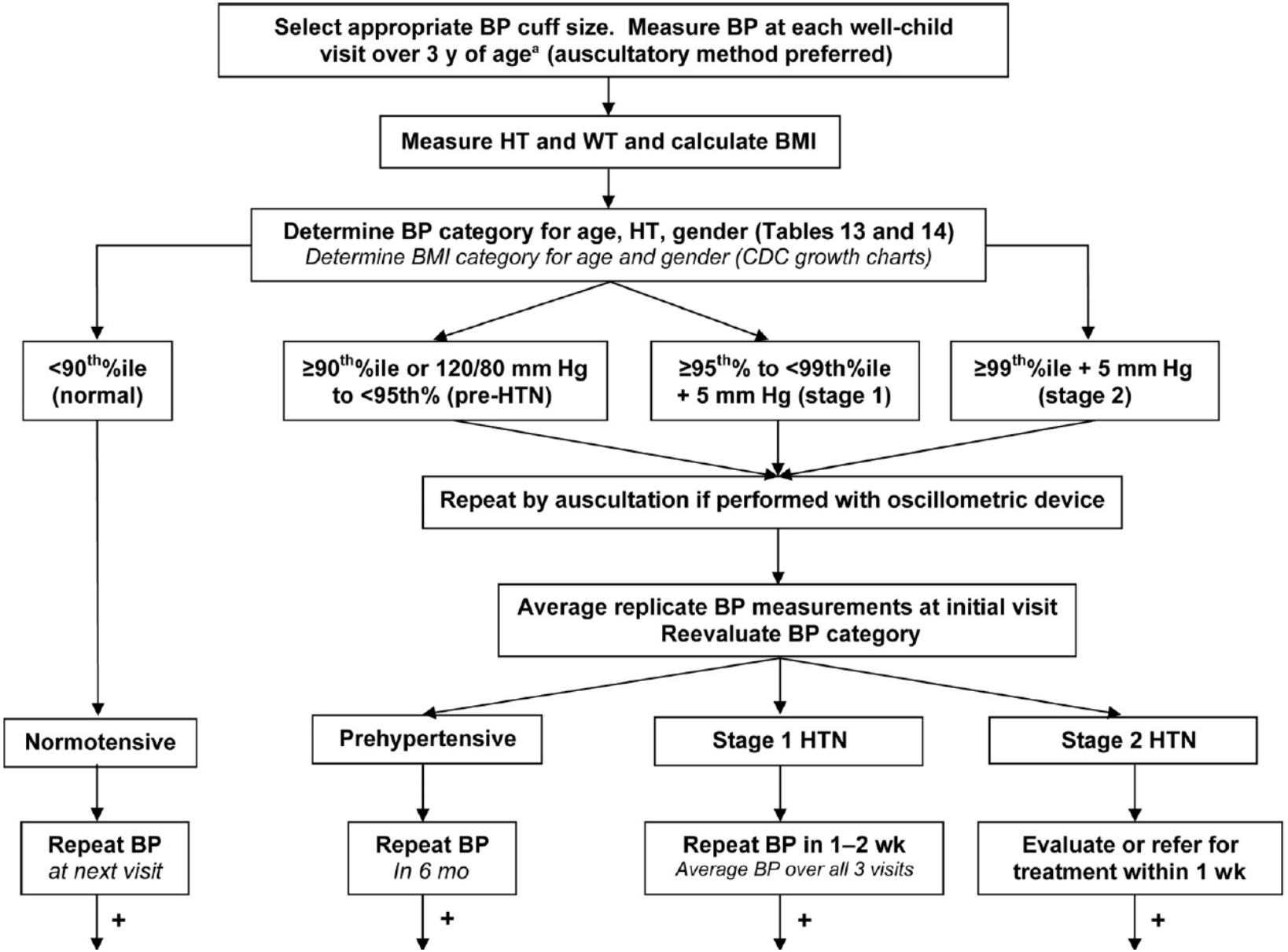
ACE indicates angiotensin-converting enzyme; QD, every day; BID, 2 times daily; TID, 3 times daily; QID, 4 times daily; CS, case series; EO, expert opinion; ARB, angiotensin-receptor blocker.

Antihypertensive drugs for severe HTN

Drug	Class	Dose*	Route	Comments
Most useful†				
Esmolol	β-Blocker	100–500 μg/kg per min	IV infusion	Very short-acting; constant infusion preferred. May cause profound bradycardia. Produced modest reductions in BP in a pediatric clinical trial.
Hydralazine	Vasodilator	0.2–0.6 mg/kg per dose	IV, IM	Should be given every 4 h when given IV bolus. Recommended dose is lower than FDA label.
Labetalol	α- and β-Blocker	Bolus: 0.2–1.0 mg/kg per dose up to 40 mg/dose Infusion: 0.25–3.0 mg/kg per h	IV bolus or infusion	Asthma and overt heart failure are relative contraindications.
Nicardipine	Calcium channel blocker	1–3 μg/kg per min	IV infusion	May cause reflex tachycardia.
Sodium nitroprusside	Vasodilator	0.53–10 μg/kg per min	IV infusion	Monitor cyanide levels with prolonged (>72 h) use or in renal failure; or coadminister with sodium thiosulfate.
Occasionally useful‡				
Clonidine	Central α-agonist	0.05–0.1 mg/dose, may be repeated up to 0.8 mg total dose	po	Side effects include dry mouth and sedation.
Enalaprilat	ACE inhibitor	0.05–0.1 mg/kg per dose up to 1.25 mg/dose	IV bolus	May cause prolonged hypotension and acute renal failure, especially in neonates.
Fenoldopam	Dopamine receptor agonist	0.2–0.8 μg/kg per min	IV infusion	Produced modest reductions in BP in a pediatric clinical trial in patients up to 12 years
Isradipine	Calcium channel blocker	0.05–0.1 mg/kg per dose	po	Stable suspension can be compounded.
Minoxidil	Vasodilator	0.1–0.2 mg/kg per dose	po	Most potent oral vasodilator, long-acting.

Summary

BP measurement & categorization



BP management