



Effect of lemon juice on blood pressure

Aysel Sari^a, Nevzat Selim^a, Melda Dilek^b, Turkan Aydogdu^b, Zelal Adibelli^b, Piltan Büyükkaya^a, Tekin Akpolat^{*b}

^aDepartment of Internal Medicine, Medical Faculty, Ondokuz Mayıs University, Samsun, Turkey

^bDepartment of Nephrology, Medical Faculty, Ondokuz Mayıs University, Samsun, Turkey

ARTICLE INFO

Article History

Received 10 / 02 / 2012

Accepted 18 / 02 / 2012

* Correspondence to

Tekin Akpolat

Ondokuz Mayıs Üniversitesi

Tıp Fakültesi

Nefroloji Bilim Dalı

Samsun, Türkiye

e-mail: tekinakpolat@yahoo.com

Keywords:

Lemon juice

Hypertension

Patient training

Drug interactions

Treatment

ABSTRACT

Lemon juice has commonly been used by hypertensive patients in order to lower blood pressure (BP) acutely when BP is raised or as an alternative/complementary therapy for expectation of chronic improvement. Grapefruit, a citrus fruit like lemon, causes clinically significant interactions with a variety of drugs including calcium antagonists. The aims of this study were to investigate acute and chronic effects of lemon juice on BP among hypertensive patients. Ninety-eight patients were included in this prospective study. Patients using calcium antagonists were not included in the study. In the acute study group, neither lemon juice nor water affected systolic and diastolic BPs. Blood pressure readings after two weeks of lemon juice were not different when compared to basal measurements. There is little information about drinking lemon juice in hypertensive patients. To our knowledge, acute or chronic effect of lemon juice on BP has not been investigated previously. This study did not show any beneficial effects of lemon juice on elevated BP. Besides, lemon juice has two potential risks for the users; drug interaction and noncompliance to the prescribed treatment. In conclusion, there is no evidence that lemon juice lowers BP at the present time and more studies are needed to investigate the effect of lemon juice on BP and possible interactions between lemon juice and drugs. Physicians should keep in mind that alternative therapies can have risks and train their patients about compliance to the treatment.

J. Exp. Clin. Med., 2012; 29:38-41

© 2012 OMU All rights reserved

1. Introduction

Hypertension is a common disease causing stroke and heart disease and affects about 1.5 billion people worldwide. Main therapies of hypertension are treatment of secondary causes, medications and life-style modifications (Chobanian et al., 2003; Mancia et al., 2007). Failure to achieve goal blood pressure (BP) is common despite remarkable advances in therapy (Chobanian et al., 2003; Altun et al., 2005; Mancia et al., 2007). Quite a lot of patients use nonprescribed drugs, herbal products, vegetables, fruits, vitamins or minerals as complementary or alternative to evidence based therapies (Betancourt et al., 1999; Wilson et al., 2002; Çapraz et al., 2007; Toprak and Demir, 2007; Adibelli et al., 2009). Traditions, cultural differences and beliefs influence patients' compliance to their treatments and usage of herbs and alternative therapies (Betancourt et al., 1999). Some hypertensive patients refrain from usage of antihypertensive drugs on influence of the beliefs such as 'drugs can cause addiction, including antihypertensives' and 'pills may be harmful because of side effects'. In

general, substances used for alternative therapy cause serious problems rarely, but can affect compliance of the patients to their treatments. We observed that lemon juice has commonly been used by our patients in order to lower BP acutely when BP is raised or as an alternative/complementary therapy for expectation of chronic improvement. The aims of this study were to investigate acute and chronic effects of lemon juice on BP among hypertensive patients.

2. Material and methods

The study assessed the effect of lemon juice on BP in two occasions: acute effect of 50 ml lemon juice given once and chronic effect of 50 ml lemon juice once daily for 14 days. Ninety-eight (80 for acute, 18 for chronic) hypertensive patients were included in this prospective study. All patients were older than 18 years old and none of them had any change in their treatment within one month preceding the study. Patients having hypertensive emergency, acute illness, pregnancy or chronic diseases such as diabetes mellitus, kid-

ney disease, and heart failure were excluded. Patients using calcium antagonists were not included in the study.

The required lemon for the study was purchased from a local market. Turkey is one of the important producers of lemon (González-Molina et al., 2010) and lemon juice used in current study was prepared from domestic harvest. A little sugar was added to lemon juice. Two different sphygmomanometers (Spacelabs 90207 and Mobil-O-Graph vers 12) were used for ambulatory BP measurement. We searched Pubmed database using key words hypertension combined with lemon, lemon juice, citrus juice, lime or lime juice without any time limitation. Friedman and Mann Whitney U tests were used for statistical analysis, and a P value of less than 0.05 was considered statistically significant. All patients were informed about the study which was approved by the Local Ethics Committee. The present study was supported by Ondokuz Mayıs University Research Fund (Samsun, Turkey).

Acute effect

Eighty patients (28 male, 52 female, mean age 54 years, range 32-77) were divided into four groups. Mean duration of hypertension was 75 months (range 1-360 months) among these patients. Mean number of antihypertensive pills that the patients were taking was 1.3. Twenty-five (31 %) of the 80 patients mentioned that they had used lemon juice for high BP before. The details of the protocol are summarized below:

1. The measurement procedure began at 9 AM.
2. After 10-15 minutes rest BP was measured. According to the first BP readings the patients were divided into two groups:
 - A. Elevated: Systolic BP \geq 140 mmHg and/or diastolic BP \geq 90 mmHg
 - B. Normal: Systolic BP < 140 mmHg and diastolic BP < 90 mmHg

The patients within each group received 50 ml of lemon juice or water randomly so that we had four groups: EL (elevated-lemon juice), EW (elevated-water), NL (normal-lemon juice), and NW (normal-water).

3. All patients lied down one hour after drinking fresh lemon juice which we prepared or same amount of water.
4. Blood pressure was measured by an ambulatory BP measurement device every 15 minutes for 24 hours.
5. All BP measurements were done from left arm.

Chronic effect

Twenty patients enrolled the study but only 18 (12 male, 6 female, mean age 55 years, range 37-68) of them were able to complete 4 weeks study period. Mean duration of hypertension was 93 months (range 12-360 months) among these patients. Mean number of antihypertensive pills that the patients were taking was 1.1. Six (33 %) of the 18 patients mentioned that they had used lemon juice for high BP before. The details of the protocol are summarized below:

1. Each patient had ambulatory BP measurement twice by using the same device.
 - A. Basal (Bas) BP: First measurement
 - B. Lemon juice (LJ) BP: Two weeks after 50 ml of lemon juice once daily at 11 AM
 - C. Free (Fr) BP: Two weeks after basal period or lemon juice period.

After basal BP measurement the patients were divided

randomly into two groups: 10 patients drank lemon juice and 8 patients had free period. At the end of two weeks the patients switched to the other period (lemon juice to free period, free to lemon juice period) following second BP measurement and third BP measurement was done two weeks later.

2. Treatment of patients did not change during the study.
3. Blood pressure was measured by an ambulatory BP measurement device every 30 minutes for 24 hours beginning from 9 AM.
4. The patients drank 50 ml of fresh lemon juice at 11 AM.
5. We gave the required amount of lemon, a squeezer, and a scale to the patients.
6. All BP measurements were done from left arm.

3. Results

Acute effect

Both systolic and diastolic BPs decreased in the elevated-lemon juice ($p < 0.05$) group, but this decline was also observed in the elevated-water group (Tables 1 and 2). There was not any significant difference between the two groups regarding decline of systolic and diastolic BPs. Neither lemon juice nor water affected systolic and diastolic BPs in the normal group (Tables 1 and 2).

Table 1. Acute effect of lemon juice on systolic blood pressure

Minutes	Group EL	Group EW	Group NL	Group NW
0	152 \pm 3	149 \pm 3	123 \pm 3	125 \pm 2
15	140 \pm 3	132 \pm 3	121 \pm 3	117 \pm 3
30	134 \pm 4	134 \pm 4	121 \pm 3	119 \pm 2
60	136 \pm 4	134 \pm 4	120 \pm 3	119 \pm 2
300	132 \pm 4	132 \pm 6	113 \pm 7	116 \pm 4

Results are expressed as mean \pm standard error of mean

EL: elevated-lemon juice, EW: elevated-water, NL: normal-lemon juice, NW: normal-water (Please see text for further explanation)

Table 2. Acute effect of lemon juice on diastolic blood pressure

Minutes	Group EL	Group EW	Group NL	Group NW
0	95 \pm 2	92 \pm 2	77 \pm 2	77 \pm 2
15	89 \pm 3	83 \pm 3	77 \pm 2	72 \pm 3
30	84 \pm 2	84 \pm 2	77 \pm 3	73 \pm 2
60	87 \pm 3	86 \pm 3	75 \pm 3	72 \pm 3
300	82 \pm 3	79 \pm 4	76 \pm 3	73 \pm 3

Results are expressed as mean \pm standard error of mean

EL: elevated-lemon juice, EW: elevated-water, NL: normal-lemon juice, NW: normal-water (Please see text for further explanation)

Chronic effect

Blood pressure readings after two weeks of lemon juice were not different when compared to basal measurements or free period measurements (Table 3).

Results are expressed as mean \pm standard error of mean
Side effects. The main problem was the sour taste of lemon juice which is softened by addition of a little sugar. A few number of patients complained of local skin problems related to cuff of sphygmomanometer.

4. Discussion

There is little information about drinking lemon juice in hy-

pertensive patients. Toprak and Demir (2007) investigated treatment choices of hypertensive patients in Turkey and reported that the most common traditional methods were eating yogurt with garlic (27.8%) and eating sour foods, such as lemon and grapefruit (25%).

Table 3. Chronic effect of lemon juice on blood pressure

Blood pressure	Lemon juice (after 2 weeks)	Basal (at the entry)	Free (after water)
Systolic, mmHg	120±2	119±3	121±3
Diastolic, mmHg	77±2	76±3	78±2

Results are expressed as mean ± standard error of mean

Adibelli et al. (2009) searched the frequency of lemon juice usage among hypertensive patients and demonstrated that 156 (72.5%) of 215 hypertensive patients were using alternative therapy and 86 patients (40%) were drinking lemon juice. Some nutrients found in lemon such as fibers, potassium, antioxidants, and flavonoids may lower BP (González-Molina et al., 2010). Lemon, sweetie fruit, orange, grapefruit, and pummelo are all citrus fruits. The number of studies investigating BP lowering effects of citrus fruits is limited (Reshef et al., 2005; Edwards et al., 2007; Díaz-Juárez et al., 2009; Perez-Vizcaino et al., 2009). In a study with sweetie fruit which has a high content of flavonoids (mainly naringin and narirutin), it was proven to be effective in the treatment of stage 1 hypertension (Reshef et al., 2005). Díaz-Juárez et al., (2009) showed that *Citrus paradisi* (grapefruit) and *Citrus sinensis* (orange) extract and juices decrease mean arterial pressure both in vitro and in vivo. Quercetin, a flavanoid present in lemon, lowers BP in several rat models of hypertension (Perez-Vizcaino et al., 2009) and stage 1 hypertensive patients (Edwards et al., 2007). To our knowledge, acute or chronic effect of lemon juice on BP has not been investigated previously.

This study did not show any beneficial effects of lemon juice on elevated BP despite common usage of lemon juice by hypertensive patients, but the study has some limitations. First, the volume of lemon juice was same for the participants, but we were not able to standardize ingredients and determine concentration of ingredients. Although we decided to use a 50 ml dose of lemon juice based on the patients' statements, the impact of different volumes or concentrations on BP can not be excluded. All of the participants were hypertensive, but the level of BP was not so high at the enrollment time of the study. More patients are required to reach a reliable conclusion for acute or chronic effect of lemon juice on BP. The study did not evaluate effect of lemon juice on BP among patients having hypertensive urgency or uncontrolled hypertension in conditions which it was used generally, but due to ethical and practical issues to conduct a study for these patients seems to be difficult. Finally, two weeks duration of treatment can be short for final conclusion.

Besides, lemon juice has two potential risks for the users; drug interaction and noncompliance to the prescribed treatment. Grapefruit juice causes clinically significant interactions with a variety of drugs including calcium antagonists. The possible mechanisms by which grapefruit juice affects metabolisms of drugs are inactivation of intestinal cyto-

chrome P450 3A4 (CYP3A4), inhibition of P-glycoprotein (P-gp), and inhibition of organic anion transporting polypeptides (Bailey and Dresser, 2004). Flavonoids (e.g. naringin, naringenin) and furanocoumarins (e.g. bergamottin, 6',7'-dihydroxybergamottin, bergapten) are nutrients found in grapefruit juice which have been implicated in the pathogenesis of grapefruit juice and drug interactions (Saito et al., 2005). Some of these ingredients have also been found in lemon with different amounts (González-Molina et al., 2005). There are reports regarding interactions between drugs and citrus juices other than grapefruit juice (Bailey et al., 2003; Lilja et al., 2005; Saito et al., 2005; Uesawa and Mohri, 2008). Orange juice-celiprolol (Uesawa and Mohri, 2008) and orange juice-atenolol (Lilja et al., 2005) are examples of juice fruit-drug interactions which can be important for hypertensive patients. It has been demonstrated that lime juice has mechanism-based inhibition of CYP3A4 activity in vitro (Bailey et al., 2003). On the basis of these findings, it is possible that lemon juice may carry some risks for hypertensive patients if it affects metabolism of drugs. The reason of the exclusion of patients using calcium antagonists from the study was possible interaction between lemon juice and calcium antagonists.

In general, the most common problem related to alternative therapies is nonadherence to the treatment as mentioned nicely by Wilson et al. (2002). The following two quotations about incompliance to the treatment were very striking for hypertensive patients (Wilson et al., 2002):

(1) "There are four pills that my doctor had given me, sitting on my counter. Instead, I take flaxseed oil and two sugar pills, and it seems to have helped me."

(2) "I've never had them (home remedies), but my dad used to take ginseng, ginger root mixed up with sugar and turpentine. He said it lowered his blood pressure. He quit taking his medicine for fifteen years."

Similar attitudes have also been observed in hypertensive patients using lemon juice. Lemon juice or formulas containing lemon juice are recommended by several sources including websites. 'I began to use lemon juice, can I discontinue my drugs' is a typical patient question that can be seen in relevant websites. Websites indicating lemon juice does not affect BP are also present. In the internet era, it is impossible to know and control that which sources will the patients read or which websites or publications will affect the patients' behaviours. Patient education is the most effective method to cope with potential problems arising from lemon juice usage and must be an important and compulsory part of therapy programs as mentioned by hypertension guidelines (Chobanian et al., 2003; Mancia et al., 2007). In conclusion, there is no evidence that lemon juice lowers BP at the present time and more studies are needed to investigate the effect of lemon juice on BP and possible interactions between lemon juice and drugs. Physicians should keep in mind that alternative therapies can have risks and train their patients about compliance to the treatment.

Acknowledgements

The present study was supported by Ondokuz Mayıs University Research Fund (Samsun, Turkey). There is no conflict of interest.

REFERENCES

- Adibelli, Z., Dilek, M., Akpolat, T., 2009. Lemon juice as an alternative therapy in hypertension in Turkey. *Int. J. Cardiol.* 135, 58-59.
- Altun, B., Arici, M., Nergizoglu, G., Derici, U., Karatan, O., Turgan, C., Sindel, S., Erbay, B., Hasanoglu, E., Cağlar, S., 2005. Prevalence, awareness, treatment and control of hypertension in Turkey (the PatenT study) in 2003. *J. Hypertens.* 23, 1817-1823.
- Bailey, D.G., Dresser, G.K., Bend, J.R., 2003. Bergamottin, lime juice, and red wine as inhibitors of cytochrome P450 3A4 activity: comparison with grapefruit juice. *Clin. Pharmacol. Ther.* 73, 529-537.
- Bailey, D.G., Dresser, G.K., 2004. Interactions between grapefruit juice and cardiovascular drugs. *Am. J. Cardiovasc. Drugs.* 4, 281-297.
- Betancourt, J.R., Carrillo, J.E., Gren, A.R., 1999. Hypertension in multicultural and minority populations: linking communication to compliance. *Curr. Hypertens. Rep.* 1, 482-488.
- Capraz, M., Dilek, M., Akpolat, T., 2007. Garlic, hypertension and patient education. *Int. J. Cardiol.* 121, 130-131.
- Chobanian, A.V., Bakris, G.L., Black, H.R., Cushman, W.C., Green, L.A., Izzo, J.L. Jr., Jones, D.W., Materson, B.J., Oparil, S., Wright, J.T. Jr., Roccella, E.J., 2003. Seventh report of the Joint National Committee on Prevention, Detection, Evaluation, and Treatment of High Blood Pressure. *Hypertension.* 42, 1206-1252.
- Díaz-Juárez, J.A., Tenorio-López, F.A., Zarco-Olvera, G., Valle-Mondragón, L.D., Torres-Narváez, J.C., Pastelín-Hernández, G., 2009. Effect of Citrus paradisi extract and juice on arterial pressure both in vitro and in vivo. *Phytother. Res.* 23, 948-954.
- Edwards, R.L., Lyon, T., Litwin, S.E., Rabovsky, A., Symons, J.D., Jalili, T., 2007. Quercetin reduces blood pressure in hypertensive subjects. *J. Nutr.* 137, 2405-2411.
- González-Molina, E., Domínguez-Perles, R., Moreno, D.A., García-Viguera, C., 2010. Natural bioactive compounds of Citrus limon for food and health. *J. Pharm. Biomed. Anal.* 51, 327-345.
- Lilja, J.J., Raaska, K., Neuvonen P.J., 2005. Effects of orange juice on the pharmacokinetics of atenolol. *Eur. J. Clin. Pharmacol.* 61, 337-340.
- Mancia, G., De Backer, G., Dominiczak, A., Cifkova, R., Fagard, R., Germano, G., Grassi, G., Heagerty, A.M., Kjeldsen, S.E., Laurent, S., Narkiewicz, K., Ruilope, L., Rynkiewicz, A., Schmieder, R.E., Boudier, H.A., Zanchetti, A., Vahanian, A., Camm, J., De Caterina, R., Dean, V., Dickstein, K., Filippatos, G., Funck-Brentano, C., Hellemsans, I., Kristensen, S.D., McGregor, K., Sechtem, U., Silber, S., Tendera, M., Widimsky, P., Zamorano, J.L., Erdine, S., Kiowski, W., Agabiti-Rosei, E., Ambrosioni, E., Lindholm, L.H., Viigimaa, M., Adamopoulos, S., Agabiti-Rosei, E., Ambrosioni, E., Bertomeu, V., Clement, D., Erdine, S., Farsang, C., Gaita, D., Lip, G., Mallion, J.M., Manolis, A.J., Nilsson, P.M., O'Brien, E., Ponikowski, P., Redon, J., Ruschitzka, F., Tamargo, J., van Zwieten, P., Waeber, B., Williams, B., 2007. Management of Arterial Hypertension of the European Society of Hypertension; European Society of Cardiology. Guidelines for the Management of Arterial Hypertension: The Task Force for the Management of Arterial Hypertension of the European Society of Hypertension (ESH) and of the European Society of Cardiology (ESC). *J. Hypertens.* 25, 1105-1187.
- Perez-Vizcaino, F., Duarte, J., Jimenez, R., Santos-Buelga, C., Osuna, A., 2009. Antihypertensive effects of the flavonoid quercetin. *Pharmacol. Rep.* 61, 67-75.
- Reshef, N., Hayari, Y., Goren, C., Boaz, M., Madar, Z., Knobler, H., 2005. Antihypertensive effect of sweetie fruit in patients with stage I hypertension. *Am J Hypertens.* 18, 1360-1363.
- Saito, M., Hirata-Koizumi, M., Matsumoto, M., Urano, T., Hasegawa, R., 2005. Undesirable effects of citrus juice on the pharmacokinetics of drugs: focus on recent studies. *Drug Saf.* 28, 677-694.
- Toprak, D., Demir, S., 2007. Treatment choices of hypertensive patients in Turkey. *Behav. Med.* 33, 5-10.
- Uesawa, Y., Mohri, K., 2008. Hesperidin in orange juice reduces the absorption of celiprolol in rats. *Biopharm. Drug Dispos.* 29, 185-188.
- Wilson, R.P., Freeman, A., Kazda, M.J., Andrews, T.C., Berry, L., Vaeth, P.A., Victor, R.G., 2002. Lay beliefs about high blood pressure in a low- to middle-income urban African-American community: an opportunity for improving hypertension control. *Am. J. Med.* 112, 26-30.